DOCUMENT RESUME

ED 119 312 EA 007 948

TITLE	Exploring Energy Conservation in Educational Facilities. Annual Conference (6th, Knoxville, Tenn., January 22, 1975, Jackson, Tenn., January 23, 1975, Nashville, Tenn., January 24, 1975).
INSTITUTION	Tennessee Univ., Knoxville. School Planning Lab.
PUB DATE	75
NOTE	37p.; Photographs may reproduce poorly
EDRS PRICE	MF-$0.83 HC-$2.06 Plus Postage
DESCRIPTORS	*Climate Control; *Educational Facilities; Electricity; *Energy Conservation; Heating; Illumination Levels; Legislation; Maintenance; School Improvement; *School Planning; *Solar Radiation; Standards
IDENTIFIERS	Tennessee

ABSTRACT

These papers presented to educators within the state of Tennessee represent the latest thinking regarding techniques for long-range energy conservation when planning and constructing school facilities. The current and future availability of energy sources is summarized. Some of the wasteful practices consumers and manufacturers have practiced are cited and suggestions made for improvement. Codes and standards related to energy use in buildings are followed by some findings of energy usage studies including illumination levels, solar energy, and ventilation. Three completed solar heating projects are described. The final paper gives some advice for the operation and maintenance of heating and air-conditioning equipment and a systematic lighting maintenance program. (MLF)

EXPLORING CONSERVATION IN EDUCATIONAL FACILITIES

SIXTH ANNUAL CONFERENCE
The School Planning Laboratory
College of Education
The University of Tennessee

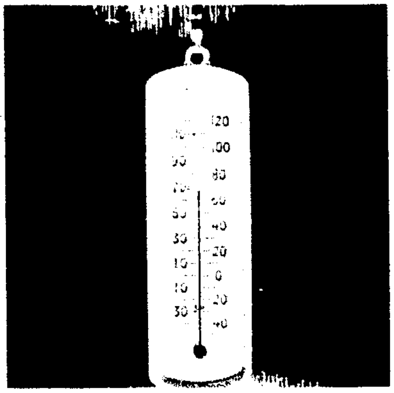
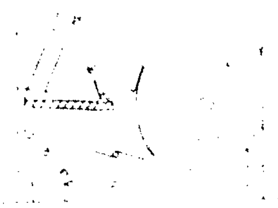
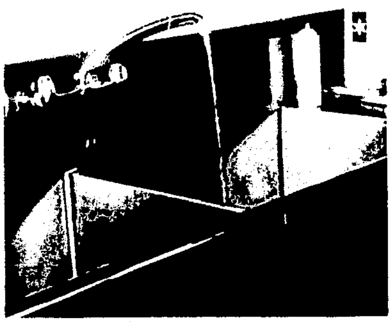


FIG. I



Full Ventilation Cooling.



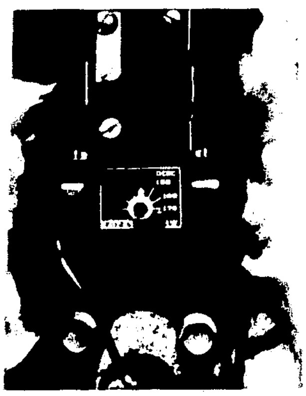
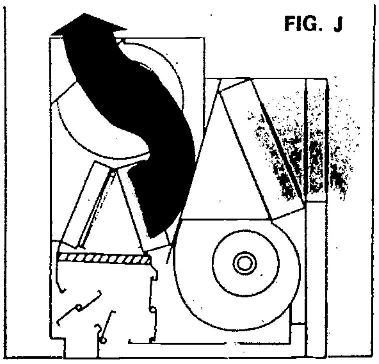


FIG. J



Refrigeration Cooling.

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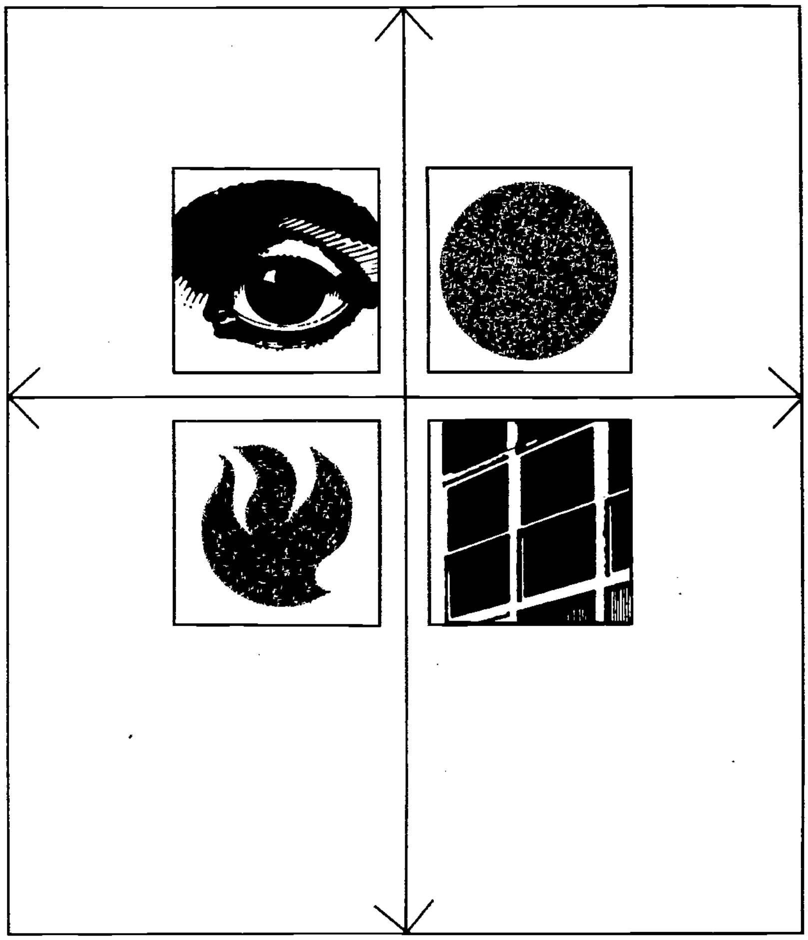
EXPLORING ENERGY CONSERVATION IN EDUCATIONAL FACILITIES



SIXTH ANNUAL CONFERENCE

JANUARY 22, 1975 AT KNOXVILLE, TENNESSEE
JANUARY 23, 1975 AT JACKSON, TENNESSEE
JANUARY 24, 1975 AT NASHVILLE, TENNESSEE

THE SCHOOL PLANNING LABORATORY
COLLEGE OF EDUCATION
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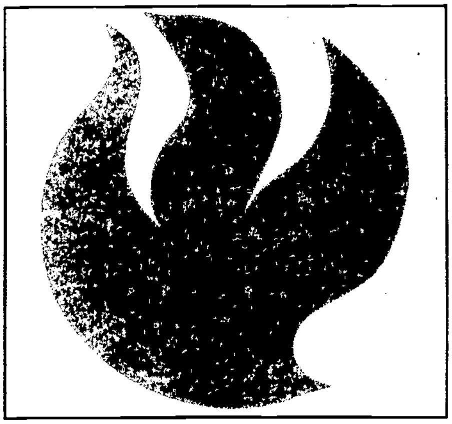

These proceedings were developed from audio tapes, written notes taken by the recorder and printed submittals from participants.

FOREWORD

Since the founding of the School Planning Laboratory (SPL) in 1961 at The University of Tennessee, the SPL has collaborated with some 260 rural and suburban school systems in twenty-four states and has served as the consultant in over 500 new school buildings, involving some 750 architects and engineers. The total cost of these projects easily exceeds one-half billion dollars.

The SPL staff has attempted to carry out three basic responsibilities in the field of educational facilities:

1. Coordinate and assist schools and colleges in the study and resolution of their educational facility problems.
2. Promote and conduct workshops and institutes and confer with educators, architects, engineers, and community leaders concerned with the planning and improvement of educational facilities.
3. Serve as a clearinghouse for the dissemination of data collected on new building concepts, equipment, and related facilities.

During this period several thousand persons have also visited the headquarters of the Laboratory to acquire better understanding of new school facilities, construction, and the renovation of old ones. In addition to these actual visitations, several thousand mail inquiries have been serviced by the Laboratory during this same period.

THE ENERGY CRISIS

Our country is facing a severe shortage of energy. The shortage could result in a stunning blow to our nation unless all of us begin now to practice energy conservation. Until American technology develops new energy sources and we can practically put them to use, we must more wisely utilize our available energy resources.

Many short term energy conservation programs have been suggested and their educational impact is difficult to assess. For example, we know that disadvantaged children tend to have a much greater retention loss during long vacations, apparently because of the differences in educational support provided in their homes. The timing of school closing, should be matched to the teaching cycle to minimize this effect. Closing mid-way through a term or semester would cause greater educational loss than closing between semesters.

The financial impact of any proposed school closing must be considered. Schools will presumably continue to meet State requirements to provide a minimum number of school days during the year (approximately 180). Most teacher contracts will probably require that teachers be paid during any winter closing, and then receive additional pay for the new school days added during the Spring or Summer. Closing schools for four additional weeks during the Winter would then add approximately 10% to school costs for the year. This will further burden school budgets which have already been increased to accommodate higher fuel costs.

Significant ripple effects may occur if energy shortages result in prolonged school closures. In addition to potential impairment of the educational progress of students, extended school closures will place extremely severe strains on the social and income maintenance systems and services in which the schools and their students, faculties and parents are involved. Day care centers can expect an immediate and significant increase in demand from single-headed families or families in which both parents work, and for which the school has therefore served a custodial as well as an educational function. These parents will be faced with a choice of leaving their jobs or finding alternative supervision for their children. To the extent that some parents will be unable to find day care openings, unemployment compensation and income maintenance expenses of the State and Federal governments will increase. School based social services will also suffer: for example, alternative means must be found for providing the nutritional services operated through the school lunch and breakfast programs, and job retraining and career education services offered by many communities through their school systems.

Other alternatives may be less detrimental to the continuity of the learning process. For example, consolidation of functions in some buildings or parts of buildings, while closing others, can save fuel and at the same time

continue most school functions. Split-sessions have frequently been used when there was a shortage of school facilities. Such sessions could be used again to save energy.

Change in operational procedures can save fuel in a variety of ways. Thermostats can be turned down, and an even greater night setback established in buildings not used for essential educational functions during evening hours. The efficiency of heating plants can be increased by careful maintenance. Measures can be taken to reduce heat loss (closing vents, keeping doors closed, installing storm windows); light can be reduced in many areas.

Educators must cope with the energy shortage in a manner which will provide quality educational programs as well as meet the social and economic needs of a community. The quality of instruction must not be sacrificed simply to meet energy needs. Long-range planning is needed to face the energy problem without losing sight of the purposes of educational programs.

Uncertainty about the future is now the most difficult problem facing educational decision-makers. Many effective energy conservation measures available to schools require advance planning. It is also quite possible that legislation and policy regulations may be instituted to cope with the real problems posed by the energy crisis. It is with these thoughts in mind that the School Planning Laboratory presents to educators within the State of Tennessee the latest thinking regarding techniques for long-range energy conservation when planning and constructing school facilities.

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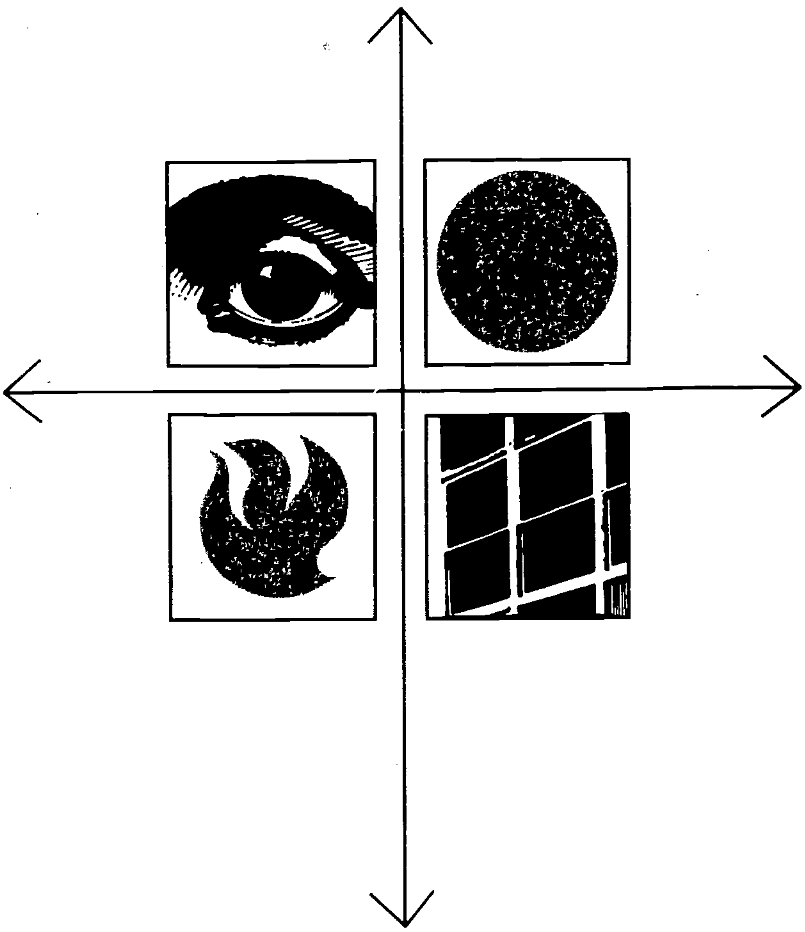


THE PROBLEM

For years Tennessee school buildings have been constructed without serious consideration being given to their insulating qualities. This was a result of the theory that added cost for heating fuel was less than the cost of insulation. It is also a result of being in a borderline area so far as severe heat or cold is concerned. School systems undertaking the task of insulating all facilities now, could require a capital expenditure which would not be readily acceptable to the taxpayer.

School administrators have diligently searched for a more economical way to heat and cool new construction. Up to this point, electricity, oil, gas, and coal have been the only available sources. Now that they all appear to be in short supply, it has been stated that the effective use of solar energy is still 20 years away. By implementing all the points of the Tennessee State Board of Education's resolution on energy conservation it is hoped to achieve a 10 per cent reduction in consumption. This is less than one half the conservation effort that has been suggested as a minimum requirement.

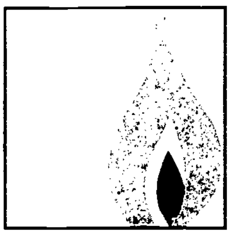
One problem is that our society has really been spoiled — cut the thermostats to 68° in all classrooms except the one where my child spends his time — he has bronchitis, tonsilitis, asthma, or is simply sensitive to cold.

Then there is the "credibility gap". Energy experts say our coal supply will be used up by the year 2000. Mr. Nader tells us his geological reports indicate we have enough to last for centuries and centuries but he is opposed to using it until we can make it burn without smoke. Other experts advise us that if it requires X amount of natural gas to heat a building, it takes 3 times that amount of gas to generate enough electricity to heat the same building.

And then there is the question of another "scare"? Major electrical distributors are already advising the public that they can relax. Has there been an error in the establishment of priorities? Some say there is a sufficient uranium supply to meet all civilian and military needs for the next 15 years. For too long school people have met to stomp out fires while doing little in the preventive, conservation or long range planning areas.

Local school budgets submitted for adoption last spring or summer have been bombarded by several state programs that dictated major adjustments. Now many are face to face with the reality that funds budgeted for heating, cooling, and transporting energies might be completely exhausted prior to completion of the fiscal year.

Everyone is aware of the present natural gas curtailments. Hearings are underway by the Federal Power Commission in Washington to determine if the reasons given for the shortage are valid. The Superintendent's Study Council on behalf of the Governor and in cooperation with the Public Service Commission and electric power distributors are participating in these hearings. Even if successful in obtaining some relief, one should recognize that it will be temporary. It appears there simply is not enough natural gas to meet our present needs, let alone accommodate future growth. A recent report by the FPC presents a realistic assessment of the natural gas supply situation.



CONCLUSIONS

A significant point that emerges from the analysis is that conventional U.S. gas production has reached its peak and will be declining for the indefinite future. This reverses a long historical record of growth and introduces a new dimension to the gas shortage. It is no longer simply a matter of gas supply failing to meet increasing requirements. It means that from here on everyone must make do with less gas in absolute terms. This is inevitable regardless of the size of the U.S. undiscovered natural gas resource base. However, the unresolved question concerning the extent of our undiscovered resource base has a direct bearing on the rate at which future production will decline. The federal government should therefore immediately undertake, or sponsor, an objective, in-depth examination of this matter in order to develop more reliable information in this critical area.

Programs designed to cope with declining production and to ameliorate the consequences of increased reliance on supplemental supplies must therefore include:

1. Mandatory natural gas conservation measures by Federal, State and local jurisdictions, for all uses of gas, including residential.

2. Allocation of gas by Federal, State and local jurisdictions to high priority and uses, such as residential, small commercial and essential petrochemical and specialized industrial uses for which no other fuel is available.

The hour is very late. The time for action is now.

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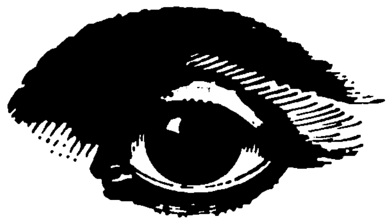
A LOOK AT ENERGY NOW



Alvin Toffler wrote a book many have probably read. It was entitled *Future Shock*. It was so popular that the title phrase has become part of our language. Toffler defined "future shock" as the disorientation, and inability to deal rationally with our environment, which stems from a greatly accelerated rate of change in society. There is hardly a better example, in our everyday lives, of this change, and the confusion it causes, than that set of conditions known generally as the Energy Crisis.

It was about two years ago that the phrase first entered public consciousness. One year ago the Arab oil embargo brought home its meaning with an impact which could never be equalled by articles in the Sunday newspaper or television documentaries. At the same time other more subtle forces influencing our energy situation began to have an effect. It was found that energy in any of its common forms was becoming more scarce and, of course, more expensive. People became, as Toffler described, disoriented by rapid change. Having to wait in line to buy gasoline, being told that the next time one flips the switch the light may not go on, or that jobs might be lost because of natural gas curtailments were unsettling, to say the least.

Before the future can be assessed, a grasp of the present is needed. In the days when David Ricardo and Thomas Malthus darkly predicted that the living standard of the mass of men could never rise above subsistence levels, economics earned for itself the title of "the dismal science." Those gloomy forecasts have long since proven inaccurate, but too many people still consider economics an extremely dismal subject, and completely ignore it. Yet it is an extremely important subject, and has much to tell about many aspects of our society, if society will only pay attention. One of the things economics can tell a great deal about is energy.

The energy crisis is normally thought of, in terms of shortages, a *gasoline* shortage, a *coal* shortage, an *electricity* shortage, a shortage of *natural gas*, etc. But one of the first lessons of economics is that there is no such thing as a shortage in and of itself. There can only be a shortage

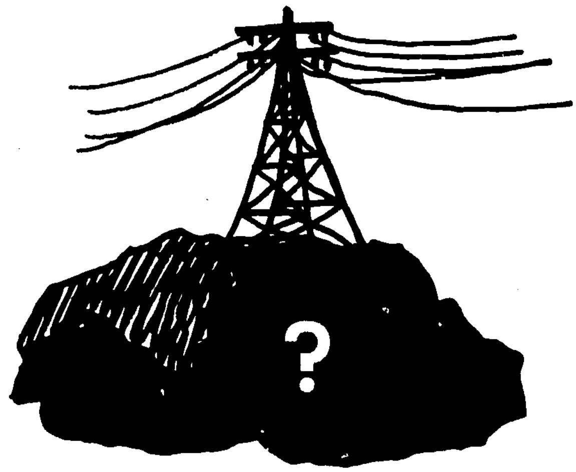
at a specified price, just as a commodity can only be in *surplus at specified price*. To solve a shortage, say the economists, raise the price. If there are no monopolies at work, demand will decrease, supply will increase, the shortage will disappear.

So when talk occurs about an energy crisis what is being said is that the price of energy is going up. It is increasing sharply because, at traditional price levels, which were very low indeed, demand outstripped supply. In Tennessee, the United States, the rest of the industrialized world, and even the underdeveloped countries, energy was a great bargain, and its use was expanded. At the same time much of the more accessible supplies of fossil fuels, particularly oil and natural gas located in the United States, were rapidly being depleted. While demand for energy at traditional prices was *increasing*, available supply was *decreasing*.

But the economists do not have the full answer. It is not enough to say, "let the price go up, and the shortage will disappear." Because energy has cost *so little* for *so long*, over-dependence has resulted. Homes, offices, factories, public buildings and transportation systems, were designed on the assumption that energy would always be cheap and plentiful. Render this assumption invalid, and lives are disrupted. Peter Drucker termed this the "age of discontinuity" To minimize these disruptions, and to begin these adjustment processes, some idea as to what the present and near future holds is needed. There are two points to emphasize. First, many of the issues affecting energy are not just economic or technical but they are legal, and *political*. Governmental leadership at both the national and state level will be crucial to our energy future. Second is another economics lesson. The terms "supply" and "demand" refer not to a single quantity. The question is not, "how much is available?", but "how much is available at some price?"

TENNESSEE'S ENERGY SITUATION

An understanding of Tennessee's energy situation begins with two considerations. The *first* is that Tennessee is not a producer of energy. The only fossil fuel of any significance is coal, of which about 7.5 million tons were produced in the year ending June 30, 1974. This is far from an overwhelming quantity, since, in contrast, the major coal-producing states such as Kentucky, West Virginia, and others, mine 50 to 100 million tons annually. A consequence is a dependence on out-of-state sources for most of the fuel supply, and it is difficult to isolate the



state situation from the national picture, or the international energy market place. Japan, for example, can and does influence coal prices in Tennessee.

The second consideration is that Tennessee is heavily dependent on electricity. Per capita consumption is about double the national average. This is due of course to the presence of the Tennessee Valley Authority, and its historically low rates for electricity. In fact, except for Washington and Oregon, beneficiaries of the Bonneville Power Project which is predominantly still producing hydro-electricity, Tennessee has the lowest rates of any state. To the extent that historical choices to use electricity are rigid, Tennessee depends on this energy type even more than the rest of the United States.

NATURAL GAS

With these two facts in mind, one can look at various fuel types, and consider what the situation is.

Natural gas is in many ways a highly desirable fuel. As many are painfully aware, it is also very hard to get right now. Gas is produced chiefly in the Southwest and moved to the rest of the country by pipeline. About 80 percent of the country's natural gas comes from Texas, Louisiana, and Oklahoma. It was once considered a useless by-product of oil exploration. As a consequence the original sales were at very low prices. As gas established itself as a valuable fuel, the Federal Power Commission stepped in to regulate its price in the *interstate* market. This regulated price for new gas is now 43 cents per thousand cubic feet, or MCF, at the wellhead. *Intrastate* sales are not regulated, and prices have gone as high as $1.58 per MCF,

though they are more commonly in the range of $1.00 to $1.25. Because of this price disparity, producers are eager to sell within their home state, so gas is more readily available and widely used in the Southwest than elsewhere. In recent years there has been increasing pressure to remove federal price controls. President Ford has urged that this be done as a means of stimulating supply. The immediate effect of this step on overall gas supplies is not clear. It *may well be* that there will be *no* increase in the short term. However, it is likely that deregulation will result in the redistribution of available supplies, with more gas going to non-producing states, including Tennessee, at higher prices. Suppose the price controls are removed and, as is not unreasonable, the well head price doubles to about 85 cents. If this increase simply flows through the consumer the price of interruptible service will increase about 70 percent, while the price of gas for residential use will increase 30 to 40 percent. This is hardly good news, but for industrial and educational consumers it is better than the current situation.

Over the longer term, deregulation of gas prices will not have a major effect on supplies. Interruptible gas for industry will ultimately disappear. Total domestic reserves, proven and estimated, are limited, and within a few years substantial imports of high-priced natural gas can be expected. As it already has been learned from the petroleum market, the U.S. Government has no control over the price of imported energy.

PETROLEUM

Petroleum provides about one third of the energy used in Tennessee. Petroleum supply is largely a question of price and political stability, rather than the physical presence of oil. The United States imports about six million barrels of oil daily, more than one third of our consumption. Much of this comes from the Middle Eastern countries. This is undesirable for two reasons: its effects on the *balance of payments* and on the *political instability* in the producing area. Oil imports cost seventy million dollars a day, almost 3 million an hour. This enormous capital outflow is placing a noticeable strain on the American economy. When added to payments made by other industrial oil-importing nations, it threatens the stability of international monetary arrangements.

The danger of becoming dependent on politically unpredictable suppliers has been well illustrated. A repetition would be disastrous.

Meanwhile, these two dangers must be dealt with. The Ford Administration has for some time been considering ways of reducing dependence on foreign oil. This will effect supplies in Tennessee, as well as elsewhere in the United States, though the impact is not likely to be severe. The President has set a goal of reducing imports by one million barrels a day. Reaching this goal would result in less than a 6 percent reduction in available petroleum. For Tennessee this would mean reducing our annual consumption from two and a quarter billion gallons of gasoline to about 2.1 billion gallons.

COAL

Coal, besides being Tennessee's only significant fossil fuel resource, is the most abundant energy source in the United States. It may well be the most difficult to get for the next few years. The coal strike is over, but there are enough problems in production and distribution to assure that coal supplies will be far from adequate for this winter and beyond. Environmental problems in both mining and burning coal now limit its usefulness and drive up the price of certain more acceptable grades. However, processes for converting coal to cleaner fuels, especially magnetohydrodynamics and synthetic gas, may ultimately alleviate some of this difficulty. More immediately, it can be expected that available coal supplies will increase, though at fairly high prices. At least some of the recent scarcity was due to the impending strike, and this factor will have been removed. Additionally, expect in the long term that the rate of production will increase in response to higher prices, and that shortages in equipment for coal transportation in this area will be somewhat alleviated.

The principal use of coal in Tennessee is electric power generation, and the principal purchaser is the Tennessee Valley Authority, which generates over 98 percent of the state's electricity. About 78 percent of this electricity is generated in coal-fired steam plants. TVA has only one operating nuclear unit which is located at Brown's Ferry, Alabama. Coal shortages have severely restricted available electricity recently. But over the longer term, the availability and cost of electricity depends on nuclear plant construction and long term cost of nuclear fuel whose price also will increase. TVA is planning only for new nuclear plants, and expects to have nuclear capacity equal to its coal-fired capacity by 1982. This is probably an optimistic estimate of the rate of construction of nuclear facilities. On the other hand, rising prices will probably

mean that historical growth rates in electrical demand will not be maintained. In fact, rapid development of solar energy could reduce residential and commercial demand.

THE FUTURE IS NOW

All this does not make a very neat package. Still, a few general conclusions are obvious. The future is now. The move is into an era when energy will be much more expensive than it has been. Recognize this and plan for it in order to deal rationally with the changed environment. This means more attention to using energy resources more efficiently and designing new facilities and making investment decisions with the life cycle as the criteria. The most important thing to learn is that the world is a more complex place than can be imagined. To naturally fear and distrust this complexity is a mistake. It is the complex ecosystem, with many interdependent parts, which is stable and healthy. The future is *now* - the energy shock is *now*. Adjust and act *now*. Decisions now will greatly determine the energy future.

Mr. Carroll V. Kroeger
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A LOOK AT ENERGY IN THE FUTURE

In general, the attempt to develop new ways of doing things goes through a series of stages. Optimistic calculations are made by technical people proving whatever scheme it may be, will be terrific. The public is then approached for support and funding. Development of electrical energy technology or gas production involves building a device that costs now $500 million. And so, it becomes expensive. To put things into context, right now the spending on energy development is less than half that spent on the race to get to the moon. So the country is less committed, at the moment, to solving its energy problems than it was to getting to the moon, which to a certain extent was a debatable necessity. The need is to solve the energy problem. Between the back of the envelope solution that is first calculated and that $500 million object that produces consumable energy lies a great valley of technology where secondary effects set in that upset the initial calculations. This has always happened. It has happened to the nuclear program which began in high hopes around 1944.

URANIUM

In the last two years we have just reached the point where uranium can produce more energy than it took to refine it. This is the kind of banner technology coming along. It didn't happen very quickly and it is rather difficult to determine what it costs. The price of atomic energy remains a hidden fact which contributes to the difficulty of decisions about future energy. In the past the cost of nuclear development was largely included in the military budget and thus cannot be separated. Five years may be needed to determine the actual cost of atomic energy. Because those who are the most knowledgeable about energy do not have the basic facts on which to base decisions, this picture of confusion will likely exist in the near future.

Neither is it known how much uranium is available in the United States. There are estimates available which were made by the old Atomic Energy Commission. These were probably underestimated by a factor of two in order to enhance the selling of the breeder reactor. This is just one of the facts of political life. A need is to find out how much uranium there is, and what it's going to cost. This probably will take a drilling program of about 5 years.

COAL

There is a tremendous amount of coal. Just how great, we are really not sure. There is a few hundred years' supply of coal, at least, if properly utilized. In exploring for zinc in Middle Tennessee, commercial operations are turning up vast amounts of coal. They are producing about $20 million worth of drilling for this geological information, but the information is not being cataloged for future use. Tennessee does not have the least notion of the mineral supply situation. This is not different from the rest of the country. The private energy industries keep this information and have been less than cooperative with attempts to find out how much coal is available.

GAS

In the gas situation, it was discovered that with the cognizance of people in the government, the owners of gas reserves were purposefully underestimating the amount of gas reserves by a sizable amount. The person responsible for this in the government had collected part of that information. He burned the information in violation of a direct order from a congressional committee and was willing to take the consequences. In Washington there have been four energy advisors in the last two years. In a space of six months, the dealing has been with three different groups from time to time. If the right direction can be discovered, and a number of multiple approaches taken to guard against failure, a workable solution for energy problems can be found, in about ten years. There is just no possibility of bringing anything in sooner unless a crash program can be initiated.

Development is still normal, which means, not wasting any money. A crash program of about double the money might be able to reduce the development time about 25 percent. To move into crash programs beyond that, probably would be wasting the taxpayers' money.

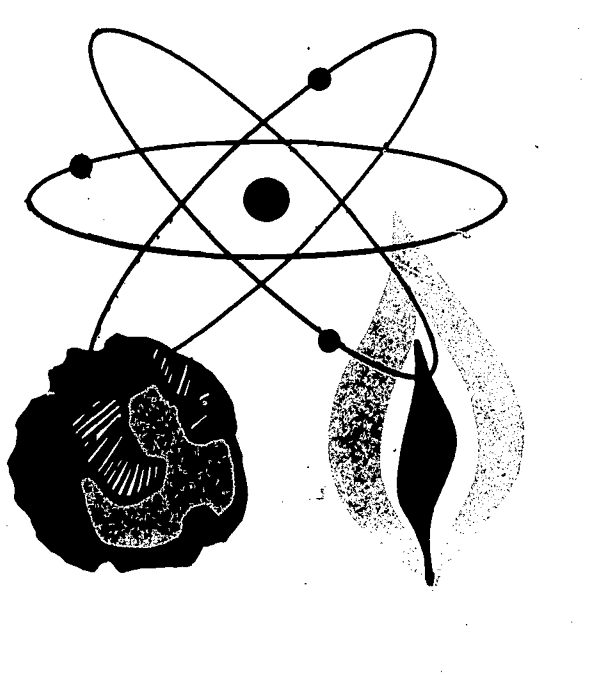
The use of natural gas should peak somewhere around 1980. The use of oil will, perhaps, peak earlier than that. These predictions may well be off by five to ten years. The gas and oil reserves are not known. The Department of the Interior is not moving expeditiously to find out. No matter how the data are handled, they show that one had better not depend on either natural gas or oil for installations that have a great lifetime. Well planned and well built school buildings certainly are likely to be in use for twenty or thirty years. This extends beyond the point where one can even hope to use natural gas or oil for heating. The use of oil, which will probably be reserved for vehicles, is going to be impractical for heating in any kind of building that is going to last for an appreciable amount of time.

ALTERNATIVES

One can hope that conservation measures are having some effect. It wouldn't help to turn out the lights in an electrically heated school building, for example, because the light is probably a more efficient heater than the heating system itself. Now a large system could burn coal directly, but installation and maintenance of the proper pollution control would be quite difficult. The technology for boilers that will clean up coal for large sized installations is progressing rather well. New models might be available in about five years.

The coal gasification development program is in serious difficulty and it's very doubtful that producing appreciable amounts of gas will come sooner than 10 years and probably not even then, unfortunately. Again, this is the valley of that technology where secondary effects not anticipated have entered into the real world and are destroying the time scales in essence.

This part of the country is going to have to rely on electrical heating. It probably will not have any other choice. TVA is now attempting to identify future demands for new electrical capacity. They are finding that electricity will



continue to replace oil and gas for heating. This is terribly bad news for the management because they really don't know where they are going to get the money to install the normal capacity to meet that demand. The cheapest version of electrical heating is a rather inefficient use of energy. The laws in conversion and transmission make the simple end use of electricity very wasteful of energy reserves. It's considerably, by several times, less efficient than an automobile engine, for example, or would be about half as efficient as burning the fossil fuel directly at your installation. Now, for more expense, however, one can install a heat pump system, provided you're talking about both air conditioning and heating. The heat pump system raises the efficiency in Tennessee roughly about three times, which is rather dramatic. The heat pump, which is about $15000 / ton roughly, raises the efficiency of an electrical system equal to that of directly burning fossil fuel.

CONCLUSION

There is no way the cost of energy is going to go down in the United States because new methods are more complicated and more costly than the existing technology. The reason for this is that the public puts anti-pollution and safety requirements on energy technology. This is virtually impossible for the technical community to react to immediately, as it takes five to ten years to build. The very difficult requirements along with the mine safety laws, making the most hazardous part of American industry a bearable place for people to work and to operate, have impacted the system. There is just no way to avoid it. There is an administrative panic, where the attack on the problem is not even well organized and is not going to be well organized at any time soon. The public has to respond well to the consequeces. It is expected they will.

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ENERGY DEMAND AND CONSERVATION

The country is blessed with energy resources, so blessed that for years a cheap and plentiful supply of energy in a variety of forms was a natural expectation of U.S. citizens. During the period from World War II until 1970 the price of energy, in essentially all forms, was a steadily decreasing fraction of our budget. That is, the cost of energy in comparison with other goods and services, kept going down, down, down. A very rational response was made to that situation. We have lots of energy and it's going to be cheap. It's so cheap that there is no need to worry about it.

A couple of things have happened that began to change very significantly this de facto national energy policy. One is, through the so-called environmental movement, the price of energy being paid was not really the total cost of that energy; that there were a lot of external costs associated with energy production that the user of that energy was not paying. An example might help. Benefits are paid for people who contracted black lung in underground mining back in the 40's and 50's. About a billion dollars a year! That's what is now paid for a cost that was surely in that cost of coal when it was mined, but it didn't appear in the price of the coal. The same on air pollution problems and many other things associated with energy production and use. In the mid 60's and the following years, that was no longer going to be the case. Internalize these costs so that the price more adequately reflected that total cost. That was the first major change in our national energy policy.

ARAB EMBARGO

Another thing happened about that same time. It was much less expensive to go overseas to obtain our additional supplies of oil and gas. It was cheaper to buy it from the Arabs, from the Venezuelans, from others around the world, and, therefore, to move overseas with operations, purchases, refining, resulted in less domestic self-sufficiency. The ratio of proven reserves divided by the annual consumption of energy was decreasing steadily. From a number, typically of twenty, that is twenty years worth of supply proven in the ground, to a number now for gas which is below nine, shows a steadily decreasing reserve in domestic supply. Low prices on interstate gas shipment were maintained to the point that there was less incentive to explore for additional gas. Therefore, less domestic supplies were built up, and, at the same time, the low price on gas was a de facto encouragement for people to use it. This caused a rapid acceleration in the consumption of gas. The national energy

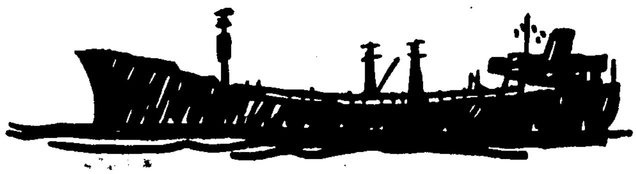
consumption pattern accelerated like a train going downhill; growth rates rising from a level of two percent in the early 50's to almost five percent in 1972. That was the setting in October, 1973 when the Arabs lowered the boom. Between the mid 60's and 1973 the nation had gone from essentially self-sufficiency to a point where it was importing more than one-third of all the oil used in addition to increasing that dependence by a million barrels per day each year. That is, each year the United States was importing an additional million barrels per day. Therefore, if the Arab embargo had hit two years from now instead of a year ago, the shortfall would not have been three million barrels per day, it would have been six million barrels a day. War could have been declared. This is the real world. The embargo was followed by an escalation in price, due, in no small part, to an international cartel of oil companies and nations, and a rapid expansion of price of oil was found that rippled back through the economy to the price of other energy resources.

WHAT TO DO

Now to face that very harsh but real fact and decide what to do about it. There is another addition to our national energy policy and that is, to get these imports down. There is no way to continue to have an outflow of American cash, particularly to the Arab states, at the rate it is going now. It will send us as close to bankruptcy as Italy now finds itself. The way to get these imports down in the

near term is even tougher than the long term. In the near term it will take fairly harsh public policies. Whether to enjoy a fair measure of voluntary response to this truly national problem or accept the thesis that Americans usually operate by mutual coercion, that is, respond as a Nation and as individuals as long as everyone else has to do the same thing is the deliberation now.

The second way to cut down on our imports is to increase the domestic supply — to move toward a sufficient degree of domestic self-sufficiency. That takes a long pe-



riod of time. It's typical in new energy supply technologies to require a quarter century of hard work before they really begin to account for something.

The last new ingredient of a national energy policy is to make an economic response to this new price situation. When the price of something changes, in this case, energy, then the rational person will try to find out what ways he can absorb that price increase in a way that costs him the least amount of money. Now, if there were no substitutes for energy, a problem would arise because there would be an inelastic response to that price change, simply because of no alternatives, and that, fortunately, is not the fact. The fact is that there are lots of alternatives, substitutes, for energy, particularly in the way to use that energy. There are lots of opportunities to use that energy more efficiently, and that's what is going on in the system now.

Another way to make that economic response to higher price is to now develop some new kinds of energy supply technologies that prior to the price change were simply not economical. There are ways to go about making new kinds of energy sources in the States, but when oil costs $4 or $5 a barrel, they simply weren't economical. At $11 a barrel, a lot of things become economical. To keep in mind that all the actions chosen to take in the area of conservation, particularly in the long run, are simply economic responses to price, will keep the situation straight. This does not mean constraining life styles, or slowing down economic viability, but maintaining that economic viability by being rational citizens. Now, there's a lot of fiction floating around that it takes x percentage energy growth rates in order to maintain a growth in the standard of living. The thing to keep in mind is doing at minimum total cost those things that are necessary to maintain a given standard of living, and as long as there are surrogates to energy, alternatives to energy use, then it's not all necessary to maintain the same growth rate in energy demand in order to maintain growth rate in our standard of living.

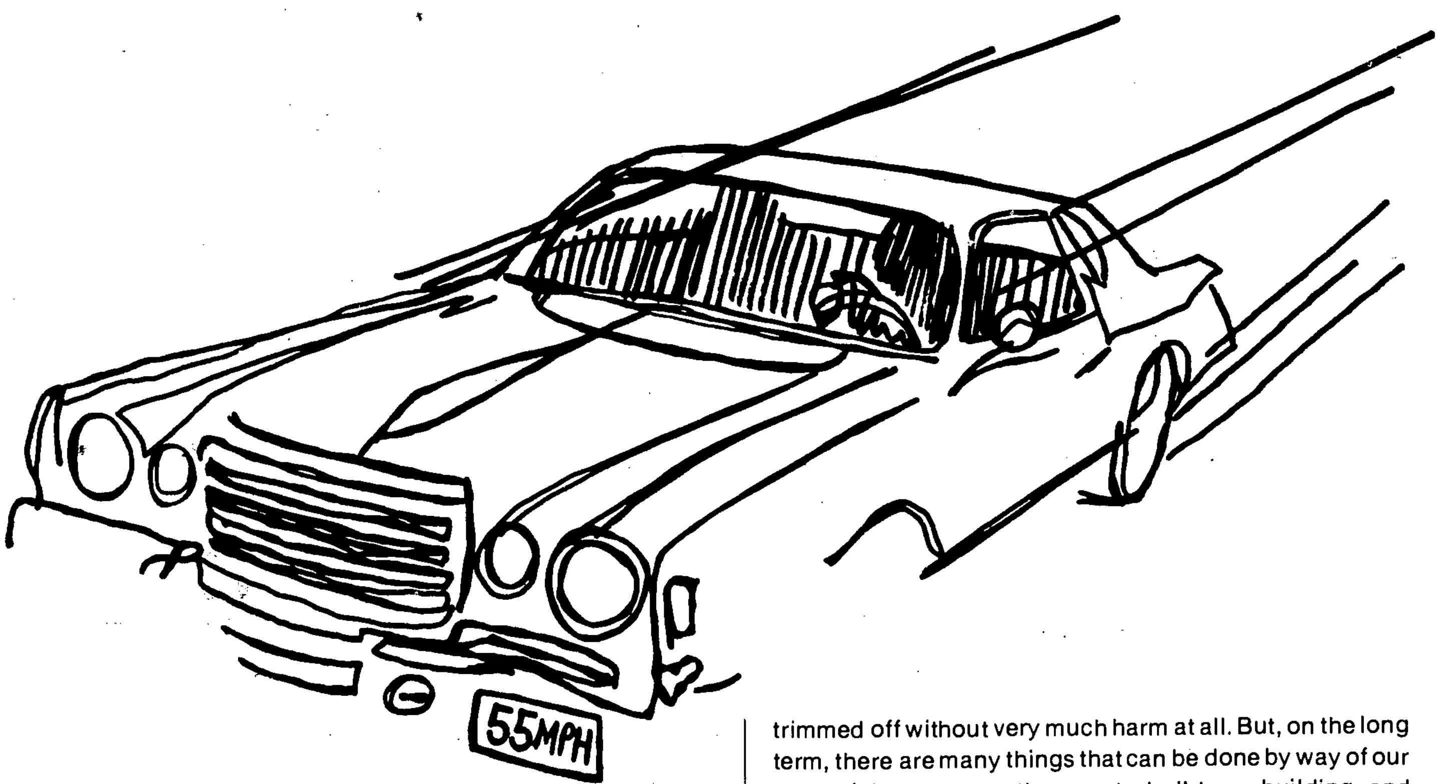
ROOM FACTORS

Think about the sectors of use of energy and about what an economic response to price means. Start with a room. The room is blessed with windows that lets light in but also leaks heat in the wintertime. The worst of all possible situations: to have windows that leak the heat, and a need to close the curtains and shut out the light. The lights have to be turned on. The room is typical of America in which energy wasn't considered when designed. To talk about being rational economic citizens, start thinking about those buildings you occupy, that you're responsible for, and the homes that we all live in, and begin to think in terms of how to save money at the bottom line — saving money through saving energy.

Think of the thermostat on the wall. More frequently than not these thermostats do not work at all, and, when they do work, they don't work very well. The thermostat is set and stays at a constant level day and night whether there are people here or not. That, typically, means that to leave the temperature the same day and night in the wintertime, is throwing away a very significant amount of energy by not spending a few more dollars on a thermostat that will move the temperature up and down depending upon whether it is day or night and whether or not people are in the room.

AUTOMOBILES

Consider the automobile. It gets about 14 miles to the gallon, if it's well tuned. Now that's a simple result of American choices in the relatively limited market and a market in which the bigger and heavier the car was the more dollar profit there was to the automobile manufacturer. That's the kind of car he would push; he still pushes it today. It has been discovered that the same amenity of travel and freedom of travel can be had but at up to twice



the miles per gallon. It doesn't come overnight. It'll take 10-15 years to do it, but there's the capability sitting out there to double the efficiency of automobiles in terms of miles per gallon if there is a commitment to that proposition.

INDUSTRIES

Look at our industries and find that the energy use has been essentially a negligible factor in many industrialist's calculus of how they worry about their costs. Energy, typically, amounted to only a small amount of the final price of the goods that an industrialist was selling. There were a few exceptions such as in the production of aluminum and paper, but generally energy cost was a small amount of the final cost. When the old energy cost becomes multiplied by a factor of three or four, then the rational industrialist looks around and finds that he is not only wasting energy but he is wasting money along with it now. He starts analyzing his factory, doing such simple things as repairing a broken window or even monitoring his stack gas on his heater or his furnace and lo and behold he finds he can save 20 or 30, sometimes 40 percent of his energy costs with relatively simple low capital cost actions in his plant. This has resulted in, in only 12 months, an increase in the output per unit energy input of our economic system in our industry of about five percent.

A five percent shift in one year is a very impressive gain, but there are many additional things one can do given a bit more time. And, given a bit more time, applies to conservation as well as it does to supply. That is, there are some actions, fortunately, that can take on the demand side that are quick, that are important, and that are effective. That's because there is essentially so much waste that there is some fat in the system that can be trimmed off without very much harm at all. But, on the long term, there are many things that can be done by way of our industrial processes, the way to build our building, and other commitments of energy that will supply us with very important gains.

EUROPEAN COUNTRIES

If we look at Sweden, West Germany, other European countries that have the same kind of per capita income that we have and the same kind of life style, one finds that the energy consumption per capita is as much as twice as low as ours. That is a real example of what our energy use could be. We could save in the long run nearly half of the energy we now use by doing something differently, and still not sacrifice our life style. The numbers are all in fair agreement that, given energy price at around 11 dollars a barrel in 1974 dollars, our total energy demand growth by the early 1980's will drop from its recent value of about 4½ percent down to a level of about 2 percent. These are simply making economic responses to that energy price and they do not imply major changes in life style.

IMPLICATIONS

What are the implications of this? It makes a very big impact in our projected requirements for energy supplies. It gives us more time to work out the newer technologies and to put them in place in the newer plants. It gives us a chance to delay on some of the capital commitments that otherwise would have to be made in order to have a new power plant on stream ten years from now. In Minnesota, school buildings are essentially uninsulated. There's a little bit of fiberglass here and there, but even in Minnesota, most of our school buildings are uninsulated. The same is true here in Tennessee. What does that mean? Don't look back and kick ourselves about that because it was done while thinking about minimizing initial cost of those buildings, and energy was cheap and plentiful. But now it's different and it's time to look back at those build-

ings and see what can be done now that an investment will pay us off in less than five years. What actions can be taken that have a return on our investment at least 25 percent? Now that beats savings and loan by a fair amount. In virtually every building there are some investments waiting for that kind of decision.

EDUCATION

Finally, the education process itself is near the center of this situation. The national energy problem is thought of as something that somehow those guys up in Washington have to solve and it's even mostly their fault. When looking at the situation one finds in helping to solve the problem, it comes back to individual actions as citizens, as homeowners, and as superintendents of school buildings. By example of what we do at school buildings, in our homes, and what we work out with the kids to take home to their parents, is the educational process itself. Translate it to the greater question of how to use resources, that is a way of a Nation, moving to a new level of sophistication and responsibility in resource management.

In going down through the last decades of this century, look back and be very grateful for one of the most important gifts that America ever received from outside its own borders. That gift was the Arab embargo because the Arab embargo brought us up short to a problem that had been rapidly escalating. It was emerging for at least ten years but in a sort of quiet way that we were all able to put aside and forget about. It brought us up sharp about three years ahead of when it otherwise would have happened. Those could be three very important years; frustrating, difficult, traumatic, but if done right, could be the best years of our lives and in this piece of this century.

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CODES AND STANDARDS RELATED TO ENERGY USE IN BUILDINGS

There are two types of energy legislation being proposed around the country. The first type, deals with amending the building codes, involving some legal questions, to require certain criteria in the design of new buildings before a permit can be issued. The second type of legislation deals with an energy or power budget which, in essence, looks past the design and past the construction into the actual energy that is used in the building. It sets some kind of magic limit of a per unit basis, on a person basis or on a per square foot basis, which should not be exceeded. If it is, the offender is penalized. There are examples of each of these already in effect and there are numerous examples being proposed.

There are tremendous pressures on legislators and on the public to pass legislation for energy conservation. Most of the legislation on buildings in the past has dealt with the protection of the life, health, and safety of the public. The concept of energy conservation adds another dimension which will be substantially tested in the courts because it affects so many segments of the American people and American industry. These segments have substantial financial stakes in these problems, and will seek the remedies of the courts if they feel wronged.

ASHRAE AND ENERGY CONSERVATION STANDARDS

There is some degree of history to the subject of providing the technical basis for energy conservation legislation. This was started about a year and a half ago when the National Conference of States on Building Codes and Standards (NCSBCS), a group comprised of representatives of all fifty states, generally in the building code areas, asked the National Bureau of Standards to prepare some kind of a document that would be the technical basis for legislation on the subject of energy conservation in new buildings. The National Bureau of Standards proceeded to develop such a document without consulting, or with very minimal consulting. As a result, they came out with a document which was immediately withdrawn. NCSBCS then turned to the private sector and asked ASHRAE to take on the development, using whatever they could salvage from the National Bureau of Standards. Understand that ordinarily in the building field, standards development from scratch usually takes a minimum of five, and many times, ten or fifteen years. In fact, most of the standards are really evolutionary. The pressures being what they were, ASHRAE was asked to see if they could develop something in a period of months. ASHRAE is pretty well down the road, but still not finished.

ASHRAE put together a committee which comprises over 100 members and about 10 subcommittees. The way in which the Committee was organized was in panels by topic. There are panels that cover the building itself, the systems that go into the building, the equipment that goes into the building, water heating, electric power, lighting, solar and wind energy, and then there is a section called "others". One of the big problems is the subject of the impact that buildings have on the natural resources, on the supply of energy. The big problem is primarily the electrical energy used in buildings, where it comes from, and how much of our natural resources it uses. This is a highly controversial subject, one which has not yet been resolved, and one which will not for some time to come.

The purpose of ASHRAE standard 90 is to enable people to design buildings with good thermal quality, and fit them out with efficient equipment and systems, hopefully allowing flexibility to provide innovation. This is something that is used for the design of buildings and not the operation.

It's intended to cover all new buildings including mobile homes and manufactured buildings. To look at some of the statistics on single family homes, one will find that in some recent years there have been more single family homes built on wheels than built on the ground.

In one or two-family and low rise multi-family residences, ASHRAE Standard 90 covers the thermal quality of the walls, the roof, the floor, and the foundation walls, based on the heating intensity required throughout the year. In most of these buildings, the heating energy requirements are fairly closely related to the duration and intensity of the winter season. In all other buildings the document deals with heat losses by degree days for walls, roofs, and floors, but, since heat gains are relatively independent of, at least dry bulb temperature, it deals with heat gains in terms of latitude. The further North one goes the less intensive the requirements. It deals with air

leakage, which is a substantial proportion in many types of buildings, of the energy requirement. Since the standard deals with buildirg products and building systems, it is obviously ridiculous to require 4½" insulation in a 3½" stud wall. Now, at some time in the future, that may be necessary, but right now there are provisions in the document for shifting the insulation around the building, so that if one can't provide the degree of insulation required in a wall or in the roof, put in what you can and put more in where you can, provided that the total heat loss or heat gain of the entire building does not exceed what it would have been had you been able to insulate it in accordance with each of these individual requirements.

HEATING AND AIR CONDITIONING SYSTEMS

When it comes to the heating and air conditioning systems, the document discussed the procedures that are used in determining the capacities required, indoor design conditions, ventilation requirements, controls, and what types of controls to have. Making provision for setback and shut-off and for zoning are discussed. The fundamental idea here is to require that the designer and the builder of the buildings incorporate those features which will permit the user to operate it efficiently. It is the user who is the key to energy efficiency, moreso than the designer, provided that he is given the tools to do it. The standard deals with simultaneous heating and cooling, which is primarily used in buildings larger than houses. Schools are a perfect example of that case. Different types of systems and under what conditions they can and can't be used, like multi-zone units, dual duct systems, reheat systems are included. Outside air for cooling, the economy cycle, minimum requirements for insulating piping and duct work, and duct construction to minimize duct leakage are likewise discussed.

In heating and cooling equipment, minimum efficiencies for electrically and heat operated cooling equipment, for heat pumps, coefficient of performance and seasonal performance factors, and maintenance labelling, requiring that the manufacturers of equipment provide labels that will instruct the user in proper maintenance procedures are included.

Service water heating equipment efficiency, and summer-winter hookups are other areas involved. One of the most inefficient ways of providing domestic hot water is a boiler that sits around all summer long, keeping the boiler hot just to provide some hot water. Insulation of domestic hot water piping, control of temperature, control of pumps

in recirculating systems and limitation of flow, in things like shower heads are discussed.

ELECTRIC POWER SYSTEMS

Also included are electric power systems, correction of power factor, minimizing voltage drop, switching of lighting, and metering of energy. It has been demonstrated, in almost every case where its been tried, particularly in the residential structures when electricity is included in the rent, the energy consumption is 10, 20, or 30 percent greater than if you make each tenant pay for it. One of the big questions to face there is to require that each tenant have the provision to be made financially responsible for the energy that he uses. If this works for electricity, won't it also work for gas? Won't it also work for steam and hot water in the central system in an apartment house? At this point it was decided to stop with an electric meter because it is reasonable and practical.

In lighting, a thing called a "lighting power budget" was set up, which, based on the use of efficient lamps and efficient lighting fixtures, an upper limit for the installed capacity of lighting equipment was established. Since the energy by lighting is a function of, not only the installed capacity, but how much it's used, provisions were made that make it possible for the occupants of the building to turn them off when they're not needed.

Many of the required things just discussed end up using more energy than they conserve. In order to comply with this document, you can take any one of two paths. Path One requires that you follow all of the preceding requirements to the letter. Path Two says that if you can demonstrate that your idea, or your innovation, will use less energy than you would have used had you followed all the requirements, you would be permitted to do it. That section then describes how you're to analyze and compute the equivalent annual, energy use. Since in small buildings, the cost of providing alternative energy use could be prohibited, excluded are all one and two family residential buildings and small commercial buildings, where temperature is controlled from a single point. There a certification by a knowledgeable professional, on what he has done to lower energy consumption, will be adequate.

For those people who wish to take advantage of solar or wind energy in their buildings, the document provides full credit for their use. If you want to use more energy to do certain things in your building and it exceeds your budget, the only way you can do it is by taking some of the burden away using non-depletable energy sources, such as solar, wind or geo-thermal.

Generally speaking, most of the things required cost money and it has taken a great deal of judgment and temperament, in order to make requirements "reasonable," insofar as economics are concerned. Recognize that this document applies to all buildings, not only to public buildings, where life cycle cost may well be in the best interest of the taxpayers, but also to speculative buildings where life cycle cost is against the interest of that builder and his profession. The requirements imposed by this document are not the total solutions to the problem.

THE ENERGY BUDGET

The next type of legislation is the energy budget. The energy budget that most people talk about today is the amount of energy used by a building. In most buildings, energy is used in two different forms, in fuel and in electricity. The energy budget of a building is expressed as the annual B.T.U.'s in the fuel that you buy, plus the annual B.T.U.'s in the electricity that you buy divided by the square footage of the building. The Federal General Services Administration suggests that for federal office buildings an energy budget of 55,000 B.T.U.'s per square foot per year is a realistic, obtainable goal. The idea behind the energy budget is good, but enforcement is a problem. The technology and the costs involved to prove compliance with an energy budget before a building is built is limited at best today, and is relatively expensive. The knowledge is being widely diffused, the cost is coming down, but the profession and the industry today is not yet at a point where we can prove compliance with an energy budget. However, the other basic problem is "Who sets the budget?" Who is going to play God and say how much energy to use? That again, creates some very difficult legislative problems.

THE POWER BUDGET

Another approach being taken is the so-called "power budget," which is now in effect in Ohio, on a trial basis for about a year. It's due to go into effect officially in 1976. It limits the installed capacity of the equipment and systems in a building. That is an erroneous way to do it because in most buildings there is no relationship between installed capacity and energy use.

It's interesting to see and note what really happens in buildings; to see what energy actually goes through the

meter or into the tank. Some data on actual buildings in operation have been collected showing their energy use and reasons examined concerning the buildings use of the energy that they do or that they don't use.

Most people are concerned primarily with seeing that the equipment installed in buildings is capable of meeting the peak loads whether it's heating, cooling, or a combination. The concept of energy use in buildings adds another dimension to the design process that is totally different in many respects to the way one has been taught to think.

The major determinant of energy use in buildings is the demand that occupants place on the buildings more than the type of system or the boilers or the chillers or the energy source. Build buildings for people, not for machines, not for glass, not for insulation, not for automation centers, and not for heat recovery.

The quantity of energy used in buildings is not necessarily related to the design mode or the installed capacity. If the installed capacity of an air conditioning system is cut by fifty percent, there's a good chance of increasing the energy consumption, not reducing it. So there is no relationship between installed capacity and energy consumption in most buildings other than houses.

ENERGY USAGE

The majority of energy use in a building occurs during a time when the outdoor temperature is moderate so that the HVAC systems, the heating and air conditioning systems are operating at part load. Conversely, a very small fraction of the energy use occurs at times when the outdoor temperature is at the annual extreme and the systems are at or near peak loads. Figure 1 will give an idea of why this occurs. This is a curve showing the annual energy use for heating and cooling a building related to outside temperatures. Note that in the 20 degree increment of temperature between 0 and 20°F., the building uses less than five percent of its annual energy. In the 20° increment between 80° and 100°, it is using about 12 percent of its annual energy. In the 20° increment from 50° to 70° the building uses about 45 percent of its annual energy.

In many types of commercial buildings, depending upon the building itself, its location, its orientation, its type and intensity of use, more insulation is not necessarily better. Information shows that energy use is not related to insulation, particularly in commercial and institutional buildings. However, the concern should be about how efficiently the heating and cooling systems operate during moderate temperatures than during extreme temperatures. This means looking at heating and air conditioning energy use as a function of different things during design. Look at energy use in terms of hours of operation because this is the primary determinant of energy use. By never operating the system, energy is not used. What runs all those hours, typically at full loads? Fans and pumps. One will find that in many buildings the fans and pumps use more energy in a year than the chillers do. In terms of heating and cooling loads, energy must be expended to satisfy the cooling loads of internal gains in the building and from external heat gains. The amount of heating energy required is a function of the heat loss, outside air flow and HVAC heating system energy requirements.

FIGURE 1

HVAC ENERGY USE AS A FUNCTION OF TEMPERATURE

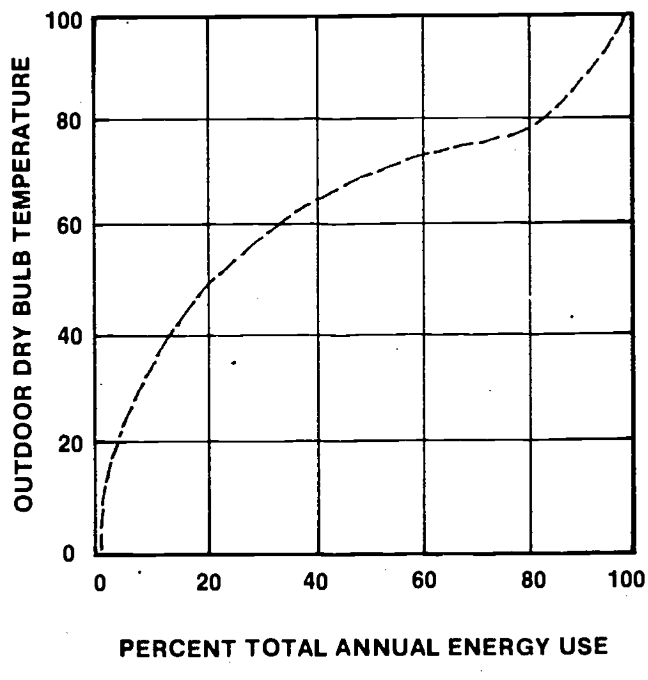
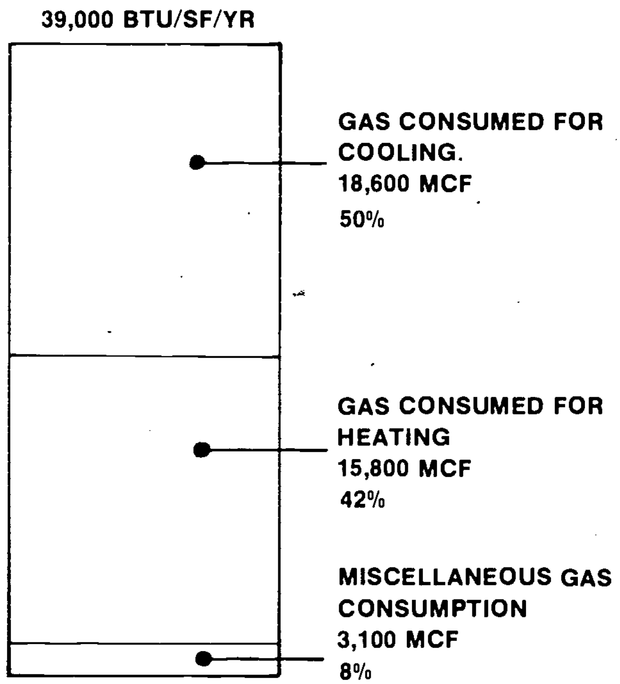


FIGURE 2

TOTAL GAS CONSUMPTION 37,500 MCF

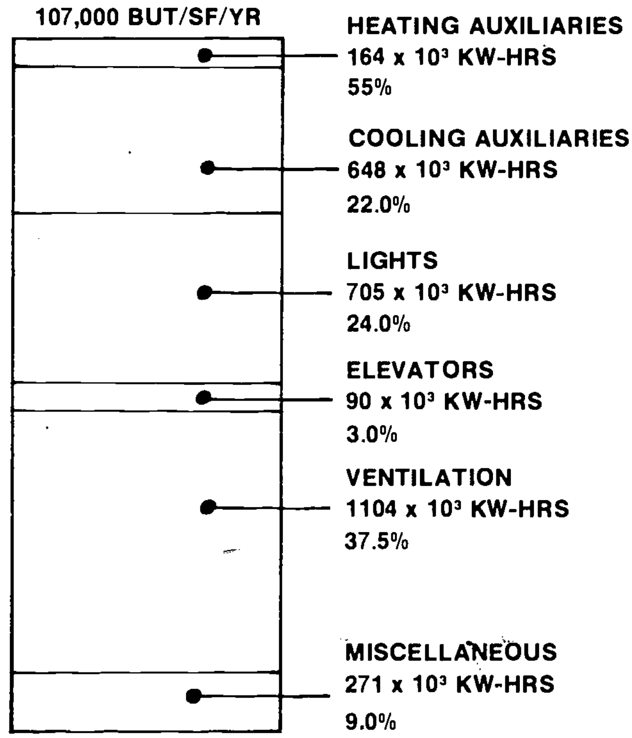


DISTRIBUTION OF EXISTING GAS ENERGY CONSUMED

FIGURE 3

ALLIED MEDICAL FACILITIES
THE OHIO STATE UNIVERSITY

TOTAL ELECTRICAL CONSUMPTION
2,983,000 KW-HRS

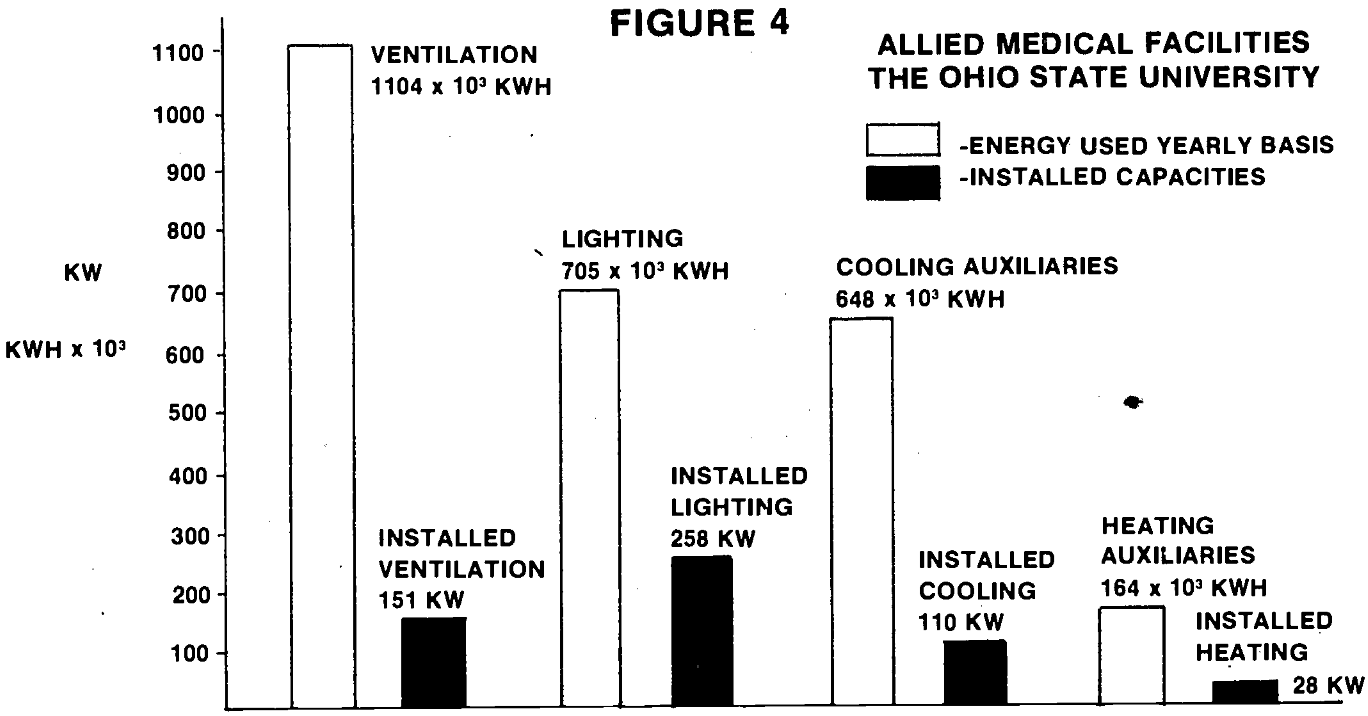


DISTRIBUTION OF EXISTING ELECTRICAL ENERGY CONSUMED

STUDY OF FAIRFAX COUNTY SCHOOLS IN VIRGINIA

Talking about something like office buildings or hospitals, there are many factors that differ from building to building, but if there ever was a class of buildings whose use tends to be relatively similar, whose programs tend to be similar, whose hours and days of operation tend to be similar, it would be schools. All of the schools in Fairfax County, Virginia, operate under virtually identical weather conditions and schedules. Generally speaking, the character of the architecture is, at least, similar. The three schools with the highest consumption are probably all-electric schools. They range from 13½¢/sq. ft. a year down to 3.8¢/sq. ft. a year, a factor of 4:1. These schools are in an area where the utility company has an electric rate of a flat 1¢/kilowatt hour with no demand charge, so that the cost is directly related to the actual energy use in kilowatt hours. The same things hold true for high schools in that same county. Even knock off the top three again, you're still going from 7½¢/sq. ft. down to 4½¢/sq. ft. which is almost 2:1.

That is the electric use and it really doesn't mean too much unless one looks at the fossil fuel energy use. About the only interesting correlation here that can be made is that generally those schools that have the highest fossil fuel energy use also have the lowest electric energy use.



COMPARISON OF INSTALLED CAPACITIES VERSUS ACTUAL YEARLY ENERGY USE

These buildings probably have conventional East Coast school house boiler plant designs and similar air side systems, which in many cases are unit ventilators. All these schools pay the same price for fuel so that these figures are directly related to fuel consumption.

OHIO STATE UNIVERSITY STUDY

Figures 2 through 4 show the results of a study on one building at Ohio State University. This particular building happens to have absorption cooling with a gas-fired boiler, which is also used for space heating. Just the gas use alone of this building is 395,000 B.T.U.'s per square foot per year. Remember, GSA said one could do the heating, cooling, lighting for 55,000 B.T.U.'s per square foot per year — this is 395,000. Figure 3 shows the electric use, which is an additional 107,000 B.T.U.'s per square foot per year for one university building. Figure 4 is the relationship between the installed capacity of the various classes of equipment and the amount of energy that the equipment uses in a year. The installed capacity of the ventilation equipment is only 151 kw, but look at the amount of energy it uses. Whereas, the lighting load is almost twice the installed capacity of the ventilation, the energy used is only about two-thirds as much. It is not the installed capacity or the design capacity, it's how much that particular system component or accessory is used that determines its energy use.

CALIFORNIA STUDY

Figure 5 shows the results of a study on three schools in one district in California built under the systems concept. It shows the variation from year to year especially when from the 71-72 school year to the 72-73 school year they endeavored to institute some energy conservation measures.

SHOPPING MALL IN PENNSYLVANIA

Figure 6 will allay a lot of questions about the energy use implications of hours of operation and type of building construction and materials. This is data from an enclosed mall type shopping center, about 50 miles north of Philadelphia. It happens to be an all-electric building, where

FIGURE 5

ENERGY BUDGETS
Huntington Beach, California

	BTU/SF/YR
Fountain Valley HS	
1970-1971	169,507
1971-1972	163,670
1972-1973	148,967
Marina HS	
1970-1971	136,275
1971-1972	143,267
1972-1973	141,908
Edison HS	
1971-1972	123,871
1972-1973	145,708

FIGURE 6

SHOPPING MALL
ALLENTOWN, PENNSYLVANIA

ALL ELECTRIC

	BTU/SF/YR
AUTO CENTER	74,000
DEPARTMENT STORE	114,000
DEPARTMENT STORE	102,000
VARIETY STORE	100,000
RESTAURANT	409,000
BANK	131,000
DRUG STORE	129,000
FOOD MARKET	205,000
DRY CLEANER	688,000
BOOK STORE	104,000
DOUGHNUT STORE	326,000

the construction of each store is identical, and each store has its own unitary all electric heating and cooling system. Each store is metered and billed individually. The shopping mall operates a fixed number of hours per day, a fixed number of days per week. All the stores are open for virtually the same number of hours. If there were ever a case where the amount of energy used would be very similar, this would be it. Yet there is a ratio of almost 10 to 1 in energy used.

There has been a movement towards establishing annual energy budgets for buildings as the basis for legislation or as guidelines for designers to meet. While such a movement is favored by many knowledgeable people, there are numerous pros and cons. In favor of the energy budget is that it establishes target energy consumptions for buildings.

The major problem is the establishment of the budget. Glancing over the preceding facts reveals the enormity of the problem. Other problems include the means for determining the budget during design, and the means for enforcement.

Various interest groups in the design and construction industries favor the energy budget as a means to "pass the buck" to other segments of the industry.

There has been a similar, but smaller movement toward the power budget, which limits the installed capacity of the energy using systems in a building. In addition to the problems facing the energy budget, the power budget concept fails to take into account the major factor in energy consumption, the use of the building.

FACTORS INFLUENCING ENERGY CONSUMPTION

The major factors in design that can influence energy consumption are the selection of the type of cooling plant, the type of air side systems, the handling of the internal heat gains (primarily lighting), the control schemes and heat recovery.

Of somewhat less importance are the energy source, the thermal quality of the building (except housing), the architecture and the type of heating system.

The major operating factors that influence energy consumption over which designers have very little control but must take into consideration when designing are the requirements and use habits of the occupants of the building, the hours of operation and whether or not there are going to be computers. Computer rooms in office buildings have been known to have energy budgets in excess of 1,500,000 B.T.U. per square foot per year.

Minor, but still important operating factors are maintenance, occupancy and the use of domestic hot water, except in housing where it can be a significant portion of the total heating energy.

In most commercial and industrial buildings, the electric bill is computed from monthly demand charts and meter readings that tell you how much energy has been used and when. This must be anticipated in the design of

the building, since the owner has to live with it for the life of the building.

By reducing the energy consumption, one may not lower the operating cost. A study was made on a large high rise office building where a system was recommended that had the highest annual energy requirements because it was not only the lowest in first cost, but the operating cost was also lower. The reason was that the owner of the building was buying district steam and there was 100% demand rate for the following 12 months. The systems that had the highest capacity and therefore the highest demand had the highest operating cost. The cost for energy used amounted to less than one-third of the annual energy bill. The other two-thirds of the bill was for demand charges which were imposed solely because of the installed capacity of the system.

CONCLUSION

The conclusion to this story is that there is no conclusion. The key to this whole business is there is no one good answer for every situation. Look at each building individually. If the answers were so simple, there wouldn't be such a wide variation of numbers as seen here.

Any consideration for legislating either power budgets or annual energy budgets must be carefully evaluated if they are to result in wise energy management.

The challenge of designing energy efficient buildings will be here for a long time to come. There are numerous significant ways in which to meet this challenge. An understanding of what happens in existing buildings contributes to the ability to do the best possible job for clients.

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LOW ENERGY UTILIZATION SCHOOL

There are certain things built into the way buildings use energy. They are built in for a number of reasons. Whether they are used properly or not becomes the next stage of the whole energy use cycle. Schools are important because they represent about seven percent of all buildings in the United States. They are fairly large energy users. Buildings in total are responsible for about 33 percent of all the energy that is used in the United States.

The concern is about the availability and use of source energy when we talk about energy utilization and energy conservation, and it makes quite a difference in the figures used particularly when one realizes that there is anywhere from a 3 to a 4:1 inefficiency in the use of electricity for heat between the source and the actual end use. It makes quite a difference in the conversion factor that one deals with.

NEW YORK CITY SCHOOLS

New York City runs about 1,000 schools, about half of them are oil-fired, and about half of them are coal-fired. They keep very good records on energy use on a month by month basis, kilowatt hours of electricity, gallons of oil, and tons of coal. The oil-fired schools used about 127,000 B.T.U.'s per square foot. This figure pertains to source energy. In New York City, Con Edison is one of the least efficient utilities in the country. It has a heat generation rate of about 12,300. In addition to that they have about a 10 per cent, as all utilities do, transmission and transformer loss; so that their heat rate is about 13,500 to produce 3,413 B.T.U.'s of efficient end use. Other utilities may be in the neighborhood of 10,000 or 11,000 in comparison.

The coal-fired schools used slightly more on the average, about 137,000 B.T.U.'s per square foot, of which the larger percentage is in heating, and less in cooling. Most of these are the older schools — schools with probably a foot and a half or two feet higher floor to floor height, with wood windows that are narrow and in very bad repair, and with caulking around the windows which is no longer effective. A good deal of the additional heat use in the older buildings is a result of both the volume of the building and the deterioration of the maintenance in the buildings themselves.

The end figures are interesting. Let's say between 125,000 and 137,000 represent about the energy content of a gallon of oil or a little bit less. In the New York City schools, they use about a gallon of oil per sq. ft. Convert

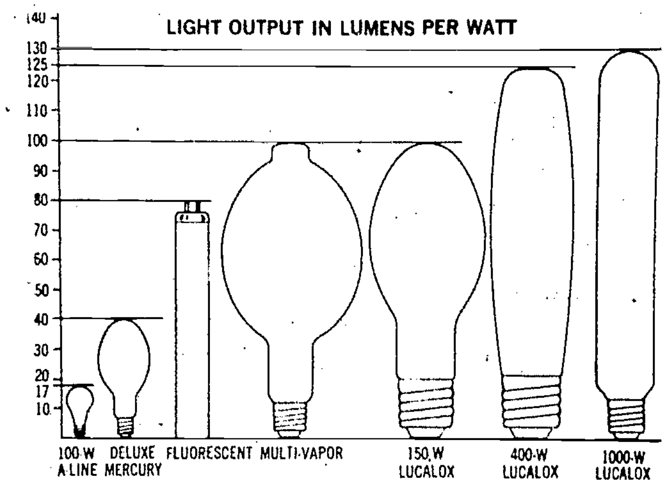
that into 35¢ or 40¢ or whatever and it begins to give you a feeling about the questions and alternatives in energy use and what both the economic and the fuel consequences are.

In addition to the general figure, careful studies were made about 16 of the buildings going into the analysis of the number or boilers, burner capacity, types of boilers, and types of ventilation equipment. There were 560 cubic feet per minute of ventilation per typical classroom. New York has a requirement of 15 cubic feet per minute per occupant and that's what generated the amount of ventilation required. Various other characteristics were noted, such as 2.4 watts per sq. ft. in the typical classroom, fluorescent fixtures, and so forth.

A graph was devised about four years ago of energy usage, both in electricity and fuel oil, which revealed the fuel oil usage is very low during the Summer months, although the schools are operated on a 12-month basis. There is a reduced Summer program, but they are open. The electricity usage is also lower in the Summer and maintains a fairly level average of about 8000 kilowatt hours per thousand square feet, and it's a fairly constant curve during the Winter months. A Division of Fuel Management gets these figures on a monthly basis. If anything looks non-typical or excessive, a team is sent out to see whether the equipment is functioning properly. It is a very carefully monitored system. It's a system that operates more efficiently on an energy use per square foot basis than any of the other systems looked at. Minnesota made an analysis of all their schools in a report which was issued about six months ago. Their typical usage is about twice the number of B.T.U.'s per square foot as used in the New York City schools. Of course, they have much more severe winters, about a thousand degree days more than New York City schools, but there isn't a difference to the extent of the fuel use difference. The peaks in the electricity usage may have been on the basis of either incorrect meter readings or projected meter readings that might not have been accurate.

WINDOWLESS SCHOOL

Another school in New York that ought to be the most energy efficient is a windowless school with individual controls in each room. The fuel oil usage is about 40% more than any of the other schools. The electricity usage is more than double the average of any of the other schools. There's one other school that is almost as high and it's also a sealed school with minimum windows. The generalization is that any school that can operate for



major parts of the time, taking full advantage of natural conditions, is inherently going to be more efficient than a school that is completely dependent on mechanical systems and mechanical cooling at all times. All the figures seen confirm that.

Suburban schools that operate on a sealed school basis use about twice the energy per square foot that the New York City schools do. The sealed school, incidently, had the greatest variation in internal conditions. The internal temperature conditions, although they were presumed to be set for the same setting on all the thermostats, varied from about 63-80° in different classrooms at the same time. The control and the responsiveness that one would expect from that system, were actually not delivered.

A quarter of the energy used in the New York City System is in lighting. A third of the energy is in the heating to replace the air that is required for ventilation, and twice as great as the heating that is required to make up for the conducted losses through the walls and roof of the building. The buildings are fairly well built to good insulation standards. However, the mandatory air change requirement constitutes in New York twice the requirement for fuel input that the heat loss through the wall of the building actually requires.

FOOT CANDLES CONTROVERSY

There's been a good deal controversy about light levels whether 60 FC, 70 FC, 120 FC, or whatever, are necessary and effective. There is a school built in 1897 with an incandescent system. The actual light levels vary from about 100 FC down to as low as 5 FC on the chalkboard wall, a 20:1 difference between the highest and lowest light levels in this room. A fluorescent lighted room, designed to have 60 FC of uniform light and the 60 FC (if you read your IES guide) is not to vary by more than 3:1 either side for any of the surrounding areas. The light levels actually varied at five feet in from the window from a thousand FC to again

35, 40, 30 and 30 at the chalkboard wall, a 35:1 difference between the highest and lowest light levels.

A converted school in which fluorescent replaced an original incandescent system, presumably to deliver a uniform 60 FC, doesn't. It varies from 90 near the window to 30 and 25 at the opposite wall. In all of these, the team that went into the classrooms, inquired as to whether anyone was aware of the light levels, whether they thought the light levels were too high, too low, bad, good whatever. Nobody was at all aware of the light levels or the variations of the light levels. They didn't have a feeling of it being good or bad, one way or another, and they were all in marked contrast to anything that's given as absolutely mandatory guides in all of the school building information that you're given. The disconnection between those standards and the delivery were very impressive in this investigation.

In a church in Sardinia, light is introduced very carefully through four inch tiny slots in the wall, and the illumination quality of light is really quite remarkable. The reflecting surface, a basal rock, gives a very soft, but effective light. The assumption is that the quality of light is something that's only readable in foot candles. The effectiveness of light has more to do with the quality of light than the quantity of light.

LIGHT LEVELS AND EDUCATIONAL ACHIEVEMENT

A very careful scientific study, over a six year period, indicated that there is very little correlation between higher light levels and greater educational achievement. Now, in order to see if some correlation between what really took place in schools and what the real light requirements were, a team went through a series of activities in the schools. These were the first twelve of some 250, each one of which has been evaluated to the amount of space, the temperature condition required, and the ventilation level required. Three ambient light levels, with a range in each were developed. The lowest was about ten footcandles for halls and circulation spaces. The next was 15 to 30, which was general classroom ambience, the other was 30 to a maximum of 50 for a highly specialized task. If there was something that required more precision than that, it became a question of analyzing a particular task at the point where it was being applied. These 250 criteria are available to anybody as a basis of determining what light levels are actually necessary, and separate the idea of an ambience background light level from a task light level. In most cases, you'll find that the ambient light level is more than sufficient for all of the educational purposes. The reason for doing this, of course, is that 25 per cent, in the New York City Schools, at least, is in light use, and by going into these variations, there's at least a 50 per cent reduction in that 25 per cent that's possible.

TASK LIGHTS IN AIRPLANES

A light delivery system in a plane, is one in which each person controls the light individually. The light is specifically directed to the task and the ventilation is also specifically and personally directed. Recently on a plane, a check was made on the light level in which everybody was reading, doing work, whatever. It was seven footcandles, but it was quite adequate for reading, and any of the general purposes one has. There is a very interesting book that probably ought to have more circulation than it does, by a man by the name of Miles Tinker, who is at the University of Minnesota. He made a series of studies on perceptivity and what the actual process is. The standards of the IES are based on instantaneous, accurate recognition of certain target figures, but that's really not the way that people read and perceive and gather that information. If may be the kind of feeling that's required for a watchmaker, but one sees things in groups of words, gets an impression of what's being said, and doesn't depend on the accuracy of the particular message. This again is a demonstration of a way that light can be delivered. Of course, a person sitting on a seat in a plane is a fixed target and it's much easier to have task lighting. The principle, however, is applicable.

At the Denver Airport there is only one out of every twelve of the corridor lights that is on and yet the general light quality is more than adequate for any purpose whatsoever. In La Guardia Airport in New York, there is about a 10' x 10' corridor with a 10 foot floor to ceiling glass wall with diffusing glass on the side of it. All of the overhead lights are on regardless. During the height of the energy shortage they apologetically had a little note that they were eliminating unnecessary lighting. They are back at the full light usage, and it's as wasteful now as it ever was.

SOLAR ENERGY

There is something else to be looked into in the study, where and to what extent, solar energy can be usable in the design of new schools and modernization of existing schools. It is very important to learn the method of building and working with best use of solar energy, but it must

be remembered that virtually every building that's built and that has been built, historically, is a solar energy building. Any building that has south orientation that captures heat when it is wanted is a solar building. Any building that has a thermal mass that retains the heat of the sun and releases it to the inside when it is wanted, is a thermal building. Any building that takes advantage of the air movement that is caused by the sun, heating one area and not heating another, and takes advantage of that air movement, is a thermal building and a solar building. The definition of a solar building as only dealing with solar collectors is really just a small part, and a distorted part, of the whole responsibility for designing with the sun and for designing with natural conditions. Frr example, if you're concerned with the capturing of the heat during the winter, if it's going to be used as an assist with the heating system or for domestic hot water take the angle that's most effective in November, December, and January. If you're concerned with the use of the energy during the summer as a heat source that can then be converted through heat pumps to a cooling cycle, then you're interested in a very steep angle of 20% off the horizontal. The angle that's most affected in the winter is closer to 45°. The purpose of collecting solar energy is more important than these absolute rules that you find in many solar guides about the ideal angle for the collectors. If one is dealing with non-concentrating collectors, there is heat all around, in the sky, in the direct sun, and the diffused sun in clouds. Even on the north facing wall, there is some solar energy that is collected throughout the year, lowest in December and highest in July.

There are interesting systems that can be developed in which the solar heat warms the mass of the building and that warm mass of the building can be converted into air movement, then directly introduced. There is a man in France by the name of Trom who developed this kind of system. A thermo-syphoning system has been developed where the heat causes a syphoning that can be introduced into the room directly without the necessity of any additional mechanical intervention. It's all powered by the convection of the air currents themselves. The same movement of the air can be used in the summer to cool the building by opening vents at the top.

In a city in New Mexico, all of the buildings are faced just slightly east to take maximum advantage of winter sunshine. All of the buildings, on the whole, are faced the same way and the maximum amount of heat is collected and introduced slowly through the heavy adobe walls.

VENTILATION

Remember ventilation was 35 per cent of the total energy used in the schools in New York, and these were based on 15 cubic feet per minute. Tests were conducted with the participation of the National Bureau of Standards to see what would happen, first of all, if the ventilation rates were cut in half, and second, if they were dropped completely. The oxygen content of the space was monitored through the whole thing. The carbon dioxide content was also monitored. There was a doctor and a psychologist in attendance. The psychologist was there to see if anybody seemed to respond to odors, which is one of the reasons that is always attributed to the higher ventilation rates. The test was conducted while a regular class was in session — 30 students in a room, through a three hour period. At the end of the period, with no ventilation on at all, the oxygen and the carbon dioxide content of the room were both well within acceptable limits. The contribution of the air that came in through the outside wall through infiltration plus the volume of air that was contained within the room both combined to effectively provide adequate conditions. The recommendation is that a maximum five cubic feet per minute be provided, and the control systems be put in so that the ventilation system is on only when the class is in session. These two things in themselves would cut down the amount of air necessary to replace air by about 75 percent. And 75 per cent of 35 per cent is 25 per cent, or 26 per cent, so that a quarter of all energy that is used, in the New York City Schools, at least with that particular air pattern, could be saved just on the basis of the reevaluation of the ventilation standards themselves.

THE ROLLAGEN

A very important energy conserving device just beginning in America, although it's been prevalent in Europe for probably 100 years, is something they call "the rollagen." They are louvered-metal blinds that are used to roll down on the outside of the windows. They serve a number of different purposes. They can be secured either with arms that raise in the awning or they can be in fixed channels along the side. First of all they cut down solar heat when you don't want it on the outside of the building. In schools they can be used very effectively as a darkening device, when you have audio-visual presentations. They can be slightly opened if there is a little tension put on them. The flaps open up and expose a series of holes that permit air to move through it without providing any draft. This is providing you have an openable window behind it. And at night, during the winter, if they're lowered, there's a dead

air space within the rollagen themselves. There's another dead air space between them and the glass and they are very effective in reducing the amount of heat that's lost through glass to the outside, when the building is not in operation. They are being installed in a community college. It should reduce the heating and the air-conditioning load by about 20 percent, which really pays handsomely in reducing mechanical costs. It did, however, add somewhat to the general construction cost.

About 15 years ago, 71 percent of the building dollar, on the average in schools, was in general construction. Now it's 66 percent. 6.9 percent was in plumbing, as opposed to 7.8 percent. 11.9 percent was in heating/ventilating which now averages almost 14 percent, and what was less than 10 percent in electricity at that time, now is over 12 percent. There's been a big shift in the proportioning of the different trades in our buildings that reflect how great a dependence on mechanical solutions and equipment solutions to solve what has formerly been solved as design problems.

These are the kinds of savings that can be projected in school buildings. Figure that 15 percent of the lighting can be eliminated, 20 percent of the ventilation requirements, about 5 percent of the 18 percent of the heating losses for better thermal performance of the walls, and virtually all of the domestic hot water requirements. This can be done through either solar or waste heat. Just arbitrarily assume that with more efficient use of systems one can save about 10 percent of the other electrical uses. On existing buildings the energy saving can be 27 percent of the total of about 50 percent of the total in new buildings. Again each individual building would have to be studied to see how effectively we could do all of this. Finally, there are a number of studies to see if there is any correlation between the age of a school, the size of the school, and the method of operation with energy use. The only trends found were the relationship of the older schools to higher fuel use because of the volume and the deterioration of the control systems within the school.

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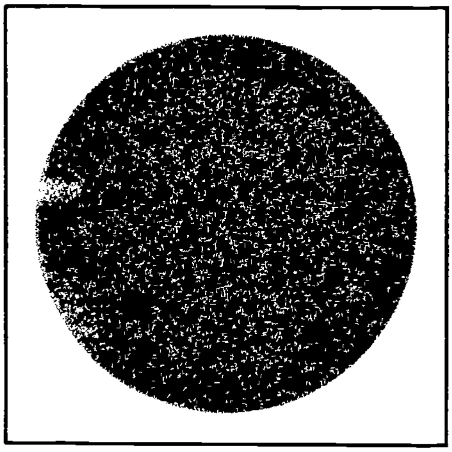
SOLAR HEATING FOR BUILDINGS

This report presents some things in the area of solar energy, where it is being applied, how effectively it is being applied and where it is being contemplated. Briefly, three completed projects are reported. The first one that has now been planned, approved and is ready for construction as soon as the bond referendum has been approved is in Fairfax County. The second one is also a project in Northern Virginia that has been installed and is operating successfully. The last one is not necessarily a solar energy project but is a proposal that Fairfax County is now seriously considering which would employ a total energy system.

The overwhelming majority of the present inventory of buildings in the United States was built without efficient use of energy as a major construction consideration. The energy consuming substances and the function within them are not exactly as efficient as they should be. Buildings use about one third the energy consumed in the United States and, available sources indicate that, about 40 percent of that is wasted. To recapture that 40 percent and use it properly, could achieve a 40 percent reduction in energy consumption in our buildings without materially compromising the environment.

THERMAL UNDERGROUND SCHOOL

Two years ago in the Fairfax County School System a somewhat unique school with a kindergarten through 8th grade for some 990 pupils was to be built. Being concerned with efficient care of energy, it was suggested to the architects that when the school was designed, they consider building the school into a hill, in such a way that the building site would be blended with the environment. In doing so, the roof of the school could be recovered as an outdoor space and play area. The building itself would be surrounded with earth on at least three sides with the front remaining open. By enlarging the school as much as possible, sufficient exposure to the outside could be provided so the children could look out and see when it was raining, snowing, or the sun shining. Unfortunately, the architect got carried away, and while using the concept to plan the school, strayed somewhat. That school does use the natural surroundings and is now a mounded structure which has two to three feet of earth all over it with penetrations on five sides. The idea was to take advantage of the natural insulation and build up the thermal mass. The building is heated, ventilated and cooled through the use of heat pumps with solar collectors being used to supplement and augment the heat pump. The calculations showing effect on energy



utilization to date are impressive and reveal the benefits of going this route. Even though the school is covered again with two to three feet of earth, it has a pleasant entrance with plenty of exposure for the children to see what's happening outside. Schools are still being designed for children as well as for energy conservation.

The school was brightened with super graphics. This kind of attractiveness continues to remind us of the need to accommodate the total environment when building schools. In order to achieve sufficient ceiling heights they simply lower the floors. To go this way cancels the exterior air temperature. The heat generated by lights and people cancels any other heat source input throughout the school year.

Refrigeration equipment is turned on to cool the load generated by the lights and people; in other words there will be times that we will need cooling even when normal schools will be requiring heating. The heat is collected in the 15,000 gallon hot water tank and temperature can be brought up to 120°. The water is used to offset the peripheral heat loss by day and maintains building temperatures at night and week-ends. Finally, the solar collector panels on the roof will provide the necessary hot water, offset the peripheral heat loss, and fill the hot water tank for night and week-end setbacks. Refrigeration equipment and outside air are used for cooling.

SOLAR SCHOOL IN WARRENTON, VA.

Another plan is the Warrenton High School again in Northern Virginia. This is one of the schools that the National Science Foundation funded. There are four of them having solar systems installed. Three of them are to augment the existing systems. Warrenton High's purpose is to completely heat five relocatable classrooms. The idea was that solar energy can be used to heat and cool public schools. It also was to demonstrate that the technology is available.

An advantage that they wanted to identify was an approximate 80 percent reduction in fuel consumption. Except for supplemental energy required to meet peak loads, fuel costs will be non-escalating. We know the sun doesn't charge any more for shining the next day and fuel supply is non-interruptible. There is low maintenance. Of course in the nation's best interest, solar energy saves the nation that much in foreign exchange and balance of payment as well as a conservation of our own fossil fuel reserves.

Some of the interesting estimates on this Warrenton High School project tell us the following costs as evaluated by the engineering firm that made the installation. The conventional systems they estimate in that particular area vary according to sophistication of the design from \$4.50 to \$6.00 a square foot. Solar heating only, Warrenton High School is estimated to be constructed and installed for anywhere from \$4.00 to \$5.00 per square foot. Solar heating and cooling can be constructed effectively for anywhere from \$6.00 to \$8.00. Finally, the record indicates at least in the Warrenton experience that the operating cost of solar heated schools is one-fifth that of conventional systems. It might well be worth spending a reasonable amount more initially because the operating and maintenance costs will be substantially reduced.

FOUR NSF FUNDED SOLAR SCHOOLS

In a town called Osseo in Minnesota on the southside of Minneapolis there is a Junior High School for which Honeywell, Inc., was awarded the contract to install a solar system for \$358,000.00. Another is Grover Cleveland Junior High School in South Boston, Massachusetts, and Warrenton High School which was mentioned earlier. Finally, the fourth is an elementary school in Baltimore, Maryland.

Getting back to the Warrenton project, the system was designed and built in 57 days even though no contractor would bid for the construction of the collector, the pump house, or the storage facility, simply because there were no drawings. The firm knew the basic rudiments and understood the engineering principles, and made their drawings as they went along. At the end of 57 days the buildings were totally heated without any assistance from any other source other than solar.

SOLAR COLLECTORS

Concerning the solar collectors, a ladder rides along on a track in order to take care of any replacement of any of the glass should that occur from vandalism. Thus far, there has only been one glass broken. It appears that something interesting is happening about the collector

which deters the children from breaking the glass. The collector is oriented to the south and is 53 degrees from the horizon. This is calculated to be the best situation for the time of the year that the greatest amount of heat was required.

The framing and the support for this entire collector was nothing more than the freight-like type. It was all built with local labor. When the solar panels are rested on their frames, there is substantial insulation between the panels, between that surface and on the sides, and the double glazing on the top. Water is pumped up through the collector at the top and down the header and hooked back into the tank. From the tank it is distributed through a loop to the places where it is needed. Directly under the pump house are 550 gallon storage tanks. They are standard manufactured tanks which were assembled on the site. The tanks are sealed, properly insulated on the side and the top to store all the energy or heat collected from the collectors, and used in several different ways. It might be interesting to note that they are using just plain water, with no additives.

In summary, I look for solar energy to be a primary source for heating and cooling in future constructed facilities, in addition to being a major assisting energy source in existing buildings.

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OPERATION AND MAINTENANCE OF FACILITIES

In order to maintain heating and air conditioning equipment in good operating condition, one of the most important things to do is keep filters clean and replace when needed. Dirty filters and coils increase operating costs. Ventilation air should be as low as needed for ventilation and odor control and turned completely off when space is unoccupied. The best way to control ventilation air is by a seven-day time clock. Fresh air intake louvers should be of good quality with low infiltration in the closed position. Thermostats should be set to the lowest temperature in winter and highest temperature in summer which will provide comfort conditioning. On heating systems, a 1-percent temperature reduction in the space is a 3 to 5 percent reduction in heating costs. All ducts outside the conditioned space should be insulated with 2" duct insulation. Water lines on hot and chilled water systems should be insulated for minimum losses. Coils on air-cooled condensing units should be kept clean and free from obstructions. Manually operated systems should have proper controls in a convenient location. Finally, if a central ventilation control wasn't installed originally, localized controls for ventilation can be added.

Regarding remodeling or replacement of heating and ventilating equipment, using decentralized units reduces first cost as well as pipe and duct losses. Individual room units save energy by more accurate temperature control and provide more operating flexibility.

HEAT PUMPS

Use heat pumps where practical. Heat pumps are the "200-percent efficiency machines" because they produce about two units of heat for each unit of energy used.

Economizer cycle — on the unoccupied cycle, the inside air damper will be fully open with the outside air intake fully closed. The face and bypass damper will be fully open to the heating elements. The heating elements will cycle on call for heating.

On the occupied cycle, the outside air damper will open to the minimum amount of air needed for ventilation. The heating elements will cycle on and off as needed for heating.

If the space temperature increases to a point where cooling is needed, the outside air damper opens to 100 percent and the indoor damper moves to the fully closed position.

If full ventilation cooling will not maintain room temperature, the outdoor air damper will close, the face and bypass damper faces off the heating elements, the minimum outside air - damper will open, and the mechanical refrigeration unit will start. On a decrease in room temperature the sequence will occur in the reverse order.

LIGHT CONSERVATION

Conservation affecting lighting would call for turning off lights when not needed for seeing purposes:

1. always with incandescent lamps,
2. with fluorescent lamps, turn off when space will be unoccupied for ten minutes or more,
3. HID lamps off at end of work or day (25-percent life reduction for each 50-percent reduction of burning hours).

Provide switches for each area or room so that lights can be turned off when not needed. Reduce lighting in hallways and other circulation spaces to about 20 percent of the level of the adjacent areas served. Substitute fluorescent lamps for incandescent lamps where possible. New sodium vapor lamp operates in many existing mercury fixtures (70 percent more light 10 percent less wattage). Use metal halide lamps in place of mercury lamps (if ballast is compatible) in submarginal lighting systems for more light without increasing energy use. (Provides 50-percent increase in light as same wattage.) Use the smallest wattage lamp which provides the level of light needed. Use light finishes on the walls, ceiling, and floors. Large dark areas absorb more light than lighter finishes. Light finishes require less wattage input for the same lighting level and render a more comfortable visual environment by providing better brightness ratios in the visual field. Recommended reflectance for interiors are:

Ceilings	80-90%
Walls	40-60%
Furniture	25-45%
Floors	20-40%

With a **systematic lighting maintenance program** greater value can be obtained from the initial lighting investment. Not only is it possible to cut the total cost of operation in dollars and cents, but you can also get even greater benefits in reducing the overall cost of light. A poorly maintained lighting system may deliver only 50 percent of the light it is capable of with proper maintenance. Here are six factors which cause light loss:

1. Lamp lumen depreciation
2. Luminaire dirt
3. Lamp outages
4. Luminous finishes
5. Room surface dirt
6. Temperature and voltage

Two factors can cut light in half. They are **lamp lumen depreciation** and **luminaire dirt depreciation.** Lamp lumen depreciation is uneconomical. To use these lamps to the end of their life is impractical as they use as much electrical energy as new lamps and give much less light.

DIRT ACCUMULATIONS

The best way to keep track of your installation is with periodic readings with a light meter. If you don't know the original lighting level, cleaning and relamping a few fixtures will give you a chance to see what your system's design was originally. Frequently, this is quite a shock since the loss of light is so gradual that it isn't noticed until it is in pretty bad shape.

The maintenance of a lighting system breaks down into two major categories: Relamping methods and cleaning.

Relamping may be accomplished on a spot basis as they burn out one at a time or they may all be replaced.

THE 80/20 PLAN

There are several ways a systematic schedule can be set up. Here is how one plan works. It is called the 80/20. Put in all new lamps. Set aside either 20 percent additional new lamps, or the best 20 percent from the ones removed.

Use Electricity Wisely

When the spares are used up for individual replacement, change the whole system again. The savings on labor should more than offset the value of lamps discarded. Regardless of how you work out the system, the benefits are there.

WATER HEATING

All hot water faucets and valves should be kept in good repair to prevent leaks of hot water. Locate hot water heaters nearest the location where water will be used. Insulate hot water pipes and tanks on all types of water heaters, including space heating systems. Install adequate storage capacity to minimize demand charges. On large loads, install equipment to defer water heating loads to offpeak hours, if possible. Finally, set thermostats on water heaters to lowest temperature required.

FOOD SERVICE CONSERVATION OF ENERGY

Preheat cooking equipment one section or burner at a time, use the least amount of equipment needed and use full loads where possible. Use the correct equipment for each cooking operation. Insulated kettles have less heat loss, and run fully loaded dish racks. Don't forget to close serving-line refrigerated cases when serving is completed. Remember not to leave hot water running, and don't leave refrigeration equipment open.

In summation, remember the energy you waste costs just as much as the energy you use wisely. Always take a look at your "energy efficiency ratio" on both present equipment and any new or replacement equipment.

Mr. Charles H. Patterson
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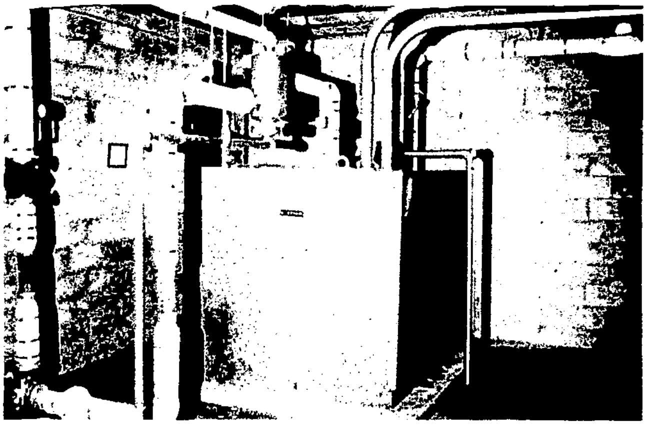

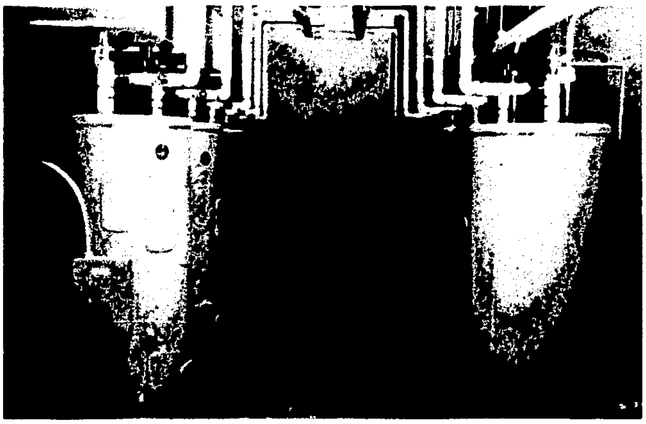


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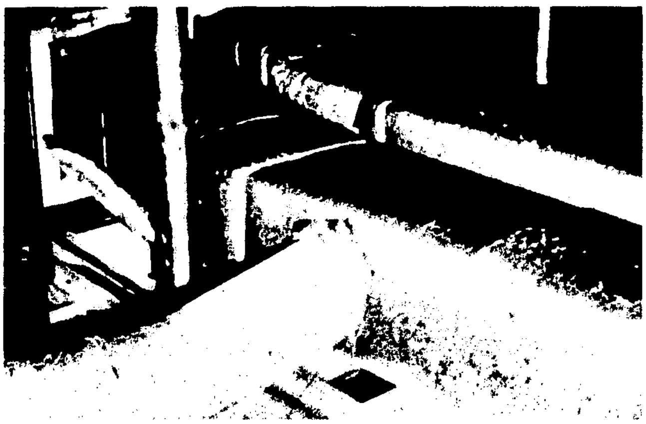

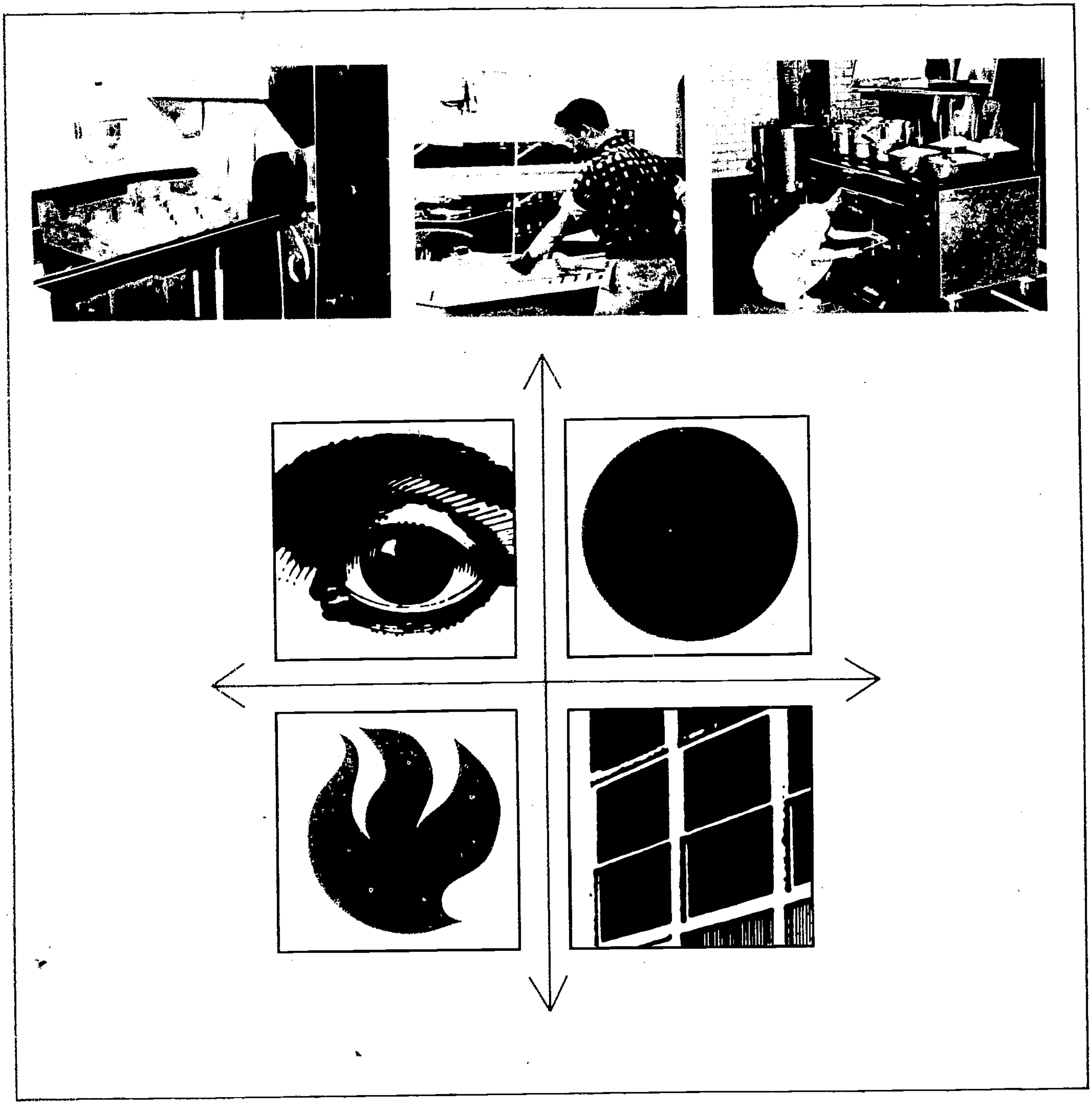

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